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VAN NOSTRAND'S

ECLECTIC

ENGINEERING MAGAZINE.

VOLUME I.

1869.

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VAN NOSTRAND'S
ECLECTIC
ENGINEERING MAGAZINE.

No. I.—JANUARY, 1869.—Vol. I.

In introducing to the Profession this novelty in engineering literature, the Publisher would respectfully submit the following considerations:

First.—Although the matter is to be selected from the professional serials, it will not largely consist of articles, nor slices of articles, merely cut out of current literature, and reprinted.

The object is, not to present specimens, but abstracts of the current fact and opinion. These abstracts are intended to be the net result—the useful impression that would remain upon the mind of an expert, after carefully reading the mass of matter from which they are derived. The condensation must, therefore, be performed more by the pen than by the scissors.

Second.—The reason why such a magazine is introduced, is that the great body of Engineers and Artisans can rarely afford the money to buy, and never the time to digest the whole volume of professional literature. Excellent and indispensable as are the few serials so widely circulated, each in its own department, they do not largely embrace other departments, and they deal too much in specifications, and details of evidence and argument, to be thoroughly read; they are rather consulted for special information, and filed for reference.

It is therefore proposed that several experts, actively engaged in different branches of the profession, and hence competent for the task, shall specially devote a part of their time to searching out and compiling such information, that all others interested may keep themselves informed in these great arts and sciences, liberally and intelligently, but also easily, agreeably, and at a small expense of money and time.

Especial effort will be made to weed out of the matter compiled, all that is irrelevant, inconclusive, and merely formal; and also to present the cardinal points, rather than the minutiæ of evidence and specification.

There are, of course, occasional leaders, papers, reports, and abstracts which should not be omitted, but which can hardly be condensed without being garbled.

The French and German magazines will be largely translated, and professional news will be gathered from all sources.

The following pages are confidently referred to, in farther explanation.

THE SITUATION.

The past year has witnessed a large development in many new and a few remarkable enterprises, and it has presented to the profession more than the usual number of revolutionary schemes and "great expectations." The rapid advancement of the Pacific Railroad, and of lines of transportation all over the world; the enlargement of communication by telegraph between innumerable little towns as well as between continents; the extension, by engineering works, of commerce and civilization at large, and more noticeably in America since our energies have been concentrated upon the arts of peace, and notwithstanding the commercial dullness due to political uncertainties, the remarkable increase of manufacturing and preparations for manufacturing in all departments;—these enterprises have fully kept pace with the requirements and the spirit of the age. It is proposed in the present article merely to refer to the condition and to the direction of progress in a few of the engineering works and problems most prominent just now in America. In a future number of the Magazine the spirit of the *new year editorials*—those careful and often excellent reviews of work done and laid out, that give so much value to the January numbers of the professional serials—will be faithfully compiled.

Railways.—A radical improvement has been commenced in locomotive practice. Ten years ago it seemed probable that engines and freight trains especially would be lightened, to save the permanent way. Meanwhile the economy of long trains, despite the rapid destruction of permanent way by the necessarily heavy engines, was established, and then, as is usually the case when the right system has been ascertained, a way—a steel way—was provided to carry it out. But the radical improvement to which we refer, although in the same direction, affects the locomotive itself. To draw heavier trains, and at the same time to decrease road wear, would seem to demand two opposite qualifications in the same machine. We may indeed set heavier boilers and machinery upon 10 or 12 driving wheels, but such a length of rigid wheel base wastes in lateral strains and frictions, what it saves in the distribution of vertical load. The "missing link" in the system was the *lateral articulation* of the locomotive, and this has now been supplied in several forms, which will be hereafter referred to. Fairlie's plan, already introduced in England and in America, is placing upon 2 independent locomotives without boilers, a single boiler capable of driving both with only the attendance required by one. Freeborn's system, which has only reached the stage of working drawings and expert indorsement, is the communication of engine-power to any number of independent trucks by means of bevelled gearing. Gearing is not a favorite word in locomotive practice, but we think its standing is likely to be improved.

Carrying 6 or 8 tons on 1 wheel in a train requires as much strength of permanent way as if every wheel bore the same load. When driving wheels carry but 2 or 3 tons each, like other wheels (and the articulation of rolling stock makes this feasible), the permanent way may be reduced in strength and cost 2 or 3 fold, and will be so reduced with advantage on lines of light traffic; or the endurance of a given weight of permanent way may be indefinitely increased. To this end, indeed, the superstructure of heavily worked lines abroad is being strengthened, while at the same time the individual strains are being reduced. All this promises economy in the working and maintenance of way and power.

It should also appear that the maximum weights of cars are reached. There are sleeping coaches on the Erie road weighing 40 tons, with 9-ton trucks. The greatest profits are made, of course, on luxuries, and railway companies can hardly overdo the matter; but we think *railway* shareholders might have a little larger interest in such profits, and that the most Golden Alhambras might be put on more wheels, or cut up into smaller Boudoirs. There is, however, a growing tendency towards lighter parts; this is accomplished by better shapes, but chiefly by the substitution of steel for iron. In England, the use of iron tyres, crank pins, rods and axles, would be considered barbarous. And in this country steel rails and tyres are introduced with commendable rapidity, and the demand for steel shapes is increasing. When iron rails break by the 1,000 a month, as on the Erie, and tests are rarely if ever required by purchasers, the necessity for subjecting steel to the most rigid and often inappropriate trials seems rather sudden; but we hope the severity of tests will rather be increased than diminished —we only ask that they may bear some relation to actual service.

Other improvements are coming forward. We can but mention them at the present writing: The close coupling of cars by elastic buffers to prevent oscillation; the interposition of elastic media between parts subjected to jarring, as in frogs and wheels; the use of interchangeable parts in rolling stock; the lateral relief of rolling stock by means of the Bissell truck and its modifications, and better workmanship, chiefly due to better tools.

Railway accommodation in the matter of car comforts, such as atmospheric air to breathe, and water to hold and transfer heat, is making notable progress; but in the matter of station conveniences, there is room for improvement—room in many instances that had better be occupied before it gets too costly. If the older London stations—Paddington, Kings Cross, etc.—were not models of fitness, the defect has been corrected in the St. Pancras station 690 feet by 240 feet under a single roof. But in the western metropolis we have no railway stations—only places on the map at or about which passengers embark or alight. This is, perhaps, not to be regretted. Any costly down-town stations in New York would only postpone the grand work that is certain to be built—a roof 1,000 feet long and indefinitely wide, in Harlem, where passengers land from underhouse or overhouse railways leading to the Battery, and whence they depart directly for the east and north, and by way of a high bridge across the Hudson for the south and west. In Philadelphia a similar grand plan is more nearly worked out. All the lines entering that city will soon terminate under a new St. Pancras on the bank of the Schuylkill, opposite the waterworks. In the western cities the building of stations has been undertaken on a liberal scale, and in many cases carried out on a permanent and suitable plan.

The disestablishment of railways, placing them under Government management, is not likely to be undertaken here at present; but the thorough discussion of the subject in England will at least reform abuses in the present system.

Meanwhile highway transportation, which has been growing more expensive and unsatisfactory for 1,000 years or more, is likely to be improved. In the vicinity of cities, light steam passenger-cars are substituted for horse-cars. Mr. Bridges Adams advocates the laying of rails on all principal highways. Notwithstanding the better adaptation of the steam-carriage to indifferent roads by means of rubber tyres, some sort of rail or tram giving a smooth, hard bearing, will be found indispensable, whatever motive power may be used. The advantages of the rail are minimum width and cost of way, and convenience in steering; its disadvantages are flange friction and inconvenience in turning out. The plank road is too perishable to be considered, except as a temporary expedient. The great American mud road is utterly bad, unnecessary, and disgraceful. In short, what we have to do is to pave the way for cheap steam power. Cheaper and quicker common road transportation is one of the most important and most neglected problems of the day; railway managers little realize what they are losing by ignoring it. Thousands of isolated villages that go to seed under the "accommodation" of a Concord coach at 4 miles an hour, would grow into large centres of traffic and revenue if connected with the nearest railway by a tram-road, upon which a 4-ton locomotive could run at 8 miles an hour. But until very lately the idea of an intermediate stage between a 100-ton train on a regulation railroad, and a lumber wagon in the mud, seems not to have been largely considered.

Iron and Steel.—It would be difficult to exaggerate the collateral advantages of the Bessemer process. Were that great art to be lost to-day, the impetus it has given to cognate arts—to invention and discovery in the treatment and means of treating iron at every stage, from the mine to the ultimate market, would have already rendered it the most important invention of modern times. We cannot undertake in this article even to mention all the promising enterprises in this direction. The Bessemer process in Europe is producing not less than half a million tons of steel per year. In America it is now fully established. After making some bad steel, and some that was unsuitable for the purposes intended, in the course of long experiments with untried irons, the mills at Troy and Harrisburg are now regularly turning out rails and shapes that are as regularly accepted after rigid tests and comparisons with the foreign steels. The Freedom and the Cleveland works have also commenced successful manufacture. Suitable ores for Bessemer steel are plentiful in all parts of the United States. But the blast furnace practice, with some exceptions, is irregular and uncertain.

One of the collateral advantages of the Bessemer process abroad, has been the creation of such a demand for pure, highly carburized, uniform pig iron, that any expense was warranted in order to meet it. And the sooner the furnace managers in this country grapple with this problem, with a determination to solve it, the better it will be for all concerned. Speaking of blast furnace practice, the hot blast, always considered economical, but not always productive of the best iron, is now deemed equally valuable for both quality and quantity. The hot blast brings down more impurities, but *suitable fluxes* eliminate these impurities. The utilization of furnace gases was at one time abandoned in certain districts, but more skilful working has removed the difficulties encountered. Indeed, in the best American practice, the detention of the gases at the tunnel head, by means of mechanical feeding apparatus, has been found unnecessary; the gases are utilized before they arrive at the tunnel head. It should certainly seem absurd to throw into the air a great volume of flame, and then complain that there is no flame-giving gas to be spared. Increased height of furnaces—over 100 feet in the Cleveland district—has largely increased the yield, and bettered the quality of pig-iron. The increased contact of the iron with incandescent carbon from this cause, is of peculiar advantage for the production of Bessemer metal. It is true that the increased temperature due to a high stack and the hot blast reduces and combines every metal of which the ore exists in the material charged—manganese, aluminium, silicum, etc.—but the greater number of the metals so reduced are valuable alloys, and the remainder may be eliminated by proper fluxing. But the capacity of the English coke to sustain the weight of the charges in a 100 feet furnace is an advantage that cannot be certainly predicted for our anthracite. It is to be hoped that the proper shaping of the boshes, and other mechanical and working features, will give us an equal advantage—or rather, it is to be hoped that our blast furnace managers will test, at some little cost, the capacities of home materials with reference to modern foreign practice. We are not doubtful as to the result, if we can only get a thorough test.

Several new processes for decarburizing crude iron are on trial. In America the mixture of magnetic ores with fluid cast-iron, and in England the pouring of crude iron upon a carbon-bearing mineral—nitrate of soda—are at least practicable substitutes for the finery process. Whether they are more than this remains to be proved, and the hopes of a wider range of interests than those directly concerned are hanging upon the results.

The development of flame furnaces, for heating and puddling, is one of the leading improvements. The Siemens furnace almost rivals the Bessemer process in practical economy. The production and burning of coal gas has been achieved by various inventors, in various ways, but the regenerative feature of the Siemens furnace enables it to maintain an intensity and a regulated quality of flame, that should preserve the material treated and the furnace itself against excessive waste. Under the Pomeroy patents, the use of manganese as a purifier, and of steam both as a heating and a purifying agent in the furnace, excellent steel is being produced from old iron rails and Franklinite ore or residuum. The Chenot steel process, depending upon the securing and utilization of the wrought-iron sponge first formed in the blast furnace, and other modes of treatment at every stage of manufacture, are having the benefit of thorough trial. The Siemens-Marten process, the production of steel of various grades from crude wrought-iron and cast-iron, in the Siemens furnace, is well established abroad, and has been successfully commenced, under favorable auspices, here.

Meanwhile the old crucible steel process, or rather the new crucible steel process, instead of being superseded by the other processes, has had the benefit of such improvements and economies, that it is still the close competitor of them all. It is fortunate for us that the best English talent and experience has found a residence among us.

For the production of steel castings, the Bessemer process is thus far inadequate—the metal cannot remain "dead melted" long enough to part with its bubble-giving gases. But the crucible process is to-day producing steel castings —gearing, frogs, cranks, and substitutes for wrought-iron forgings, that are excellent substitutes for forgings, in every particular. This manufacture is so new among us that we hardly appreciate its importance.

In the machinery for working iron and steel, we have more metal and better fitting. The steel rail train at Harrisburg and the new iron trains at Reading are as ponderous and accurate as marine engine work. We have but few heavy steam hammers in this country, and no hydraulic forging presses. The use of wrought-iron box-frames for hammers, cranes, etc., has hardly commenced here, although it is common abroad.

Steam Navigation has experienced no radical change of late. The size of ships is creeping up to Great Eastern proportions. The greater the size, the less the working cost for a given speed; always provided the vessel is loaded to her full capacity. The Great Eastern is simply premature. A most important change in the structure of iron hulls is hardly recognized by the leading builders, strange to tell, although long since brought forward. This is the longitudinal system—running the ribs lengthwise instead of vertically, so as to add their enormous strength in the direction of the principal strain. No amount of strength in the present vertical frames of a ship will prevent her breaking in two. In marine engines and boilers there is little change, although there has been much costly experimenting. Excessive superheating, surface condensation, high-pressure, and the use of liquid fuel, are slow and difficult problems. Wood bearings have overcome the chief obstacle in the working of heavy screw machinery, and the screw steamer is driving the paddle steamer from the sea. With the screw the power of the wind can be added to that of steam, but paddles work at a disadvantage in a vessel rolling and careening under a spread of canvass,

Iron Structures, bridges, houses, etc., are multiplying among us. On the principal railways, such as the Pennsylvania, the wooden bridge is the exception. If the old wooden trusses and trestles so common on the older American roads, are not soon pulled down, there will be some frightful "accidents." We regret to observe that so many costly buildings are going up in our cities with wooden floors. We think it could be proved that iron would pay in the long run, at twice its present cost. A little economy of external and as a rule inappropriate ornamentation, would pay for fire-proof and durable floors.

New Sources of Power.—Captain Ericsson's startling proposition to utilize the direct heat of the sun, has been published, and, in fact, practised on an experimental scale during the past year. The foreign authorities do not receive the announcement hopefully and with proper respect, but they are accustomed to sudden conversions, as in the matter of the monitors. The application of tides and wind to mechanical uses has hardly been advanced. Here are three forms of power—infinite, universal, and free—going to waste century after century, while we are delving in the depths and under the sea for costly coal to convert into power. We cannot believe that the limit of human ingenuity is reached—rather that these subtle forces are held in reserve for the uses of a wider and grander civilization.

THE NEW YORK SOCIETY OF PRACTICAL ENGINEERING.

This Society, organized a few months since, holds regular fortnightly meetings at room 24 Cooper Institute building, for the discussion of engineering subjects of a practical nature and of public interest. Meetings were held on the evenings of November 24 and December 8 respectively, the President (James A. Whitney) in the chair.

At the meeting of the 24th ult., the regular paper on "Elevators and Hoisting Machinery" was read by Mr. T. P.

Pemberton. The writer passed from a brief consideration of the most primitive methods of raising weights by means of a rope thrown over the branch of a tree to the construction of the rude capstans and windlasses that, until within the past hundred years, were used on the vessels and in the mining operations of most nations, and are still found on Chinese junks. From this he passed to a classification and description of the several classes of elevators now employed in mines, buildings, manufactories, etc. The use of traversing cranes for large workshops was strongly advocated, and sketches given of those employed in England, and capable of lifting and carrying a large locomotive from one end of the shop to the other. The use of ropes, either of hemp or wire, in elevators for carrying persons was discountenanced, and elevators worked by screws were recommended for all such cases. In the discussion which followed, a method was explained by which it is believed large, masses of rock were lifted in ancient times, and which consists in tilting the rock alternately upon each of two fulcrums placed at a slight distance apart under the centre of the mass, each fulcrum being slightly raised as the rock was tilted up therefrom. An elevating apparatus which is used in Great Britain, and to some extent in American mines, was described as consisting of two vertical series of platforms, having an alternate reciprocating movement in opposite directions, so that by stepping to and from the platforms of one series to those of the other, the miners, by the upward movement of the platforms, may be carried from the bottom to the top of the shaft.

At the meeting of the 8th inst., the regular paper on "Modern Improvements in Mining Apparatus" was read by Mr. Wm. B. Harrison, and sketched the development of machinery in mining operations from the primitive wash-pan to the modern improvements in stamp-mills, amalgamators, and the like. An interesting discussion sprang up after the reading of the paper, in which Dr. A. W. Hall sketched his experience in the mining districts of the Rocky Mountains, and the economy which has resulted in the amalgamating process, by placing the mercury as a coating upon copper. A Mr. Ferris, from California, gave a detailed description of the method of hydraulic mining in that State. Dr. J. N. C. Smith, ex-Mayor of Boston, gave a graphic description of what had fallen under his observation in travels in Asia, stating his belief that unknown mines still exist in that ancient country, and giving also a sketch of a rude turbine wheel which he had seen in one of the valleys of Anti-Lebanon, and which had been in use there for ages before American turbines were thought of. After some further discussion on ancient and modern appliances relating to the matter in hand, the Society adjourned for two weeks, with the announcement that at the next meeting the regular subject for consideration would be "The Prevention of Marine Disasters."

ENGINEERING PROBLEMS.

The Council of the Institution of Civil Engineers invite communications on the subjects comprised in the following list, as well as upon others; such as, 1st. Authentic Details of the Progress of any work in Civil Engineering, as far as absolutely executed (Smeaton's Account of the Eddystone Lighthouse may be taken as an example); 2d. Descriptions of Engines and Machines of various kinds; or, 3d. Practical Essays on Subjects connected with Engineering, as, for instance, Metallurgy. For approved original communications the council will be prepared to award the premiums arising out of special funds devoted for the purpose.

1. On the present state of knowledge as to the strength of materials.

2. On steam cranes, and on the application of steam power in the execution of public works.

3. On the theory and details of construction of metal and timber arches.

4. On land-slips, with the best means of preventing or arresting them, with examples.

5. On the principles to be observed in laying out lines of railway through mountainous countries, with examples of their application in the Alps, the Pyrenees, the Indian Ghâts, the Rocky Mountains of America, and similar cases.

6. On railway ferries, or the transmission of railway trains entire across rivers, estuaries, etc.

7. On the systems of fixed signals at present in use on railways.

8. Description of a modern English locomotive engine, designed with a view to cheapness of construction, durability, and facility of repair.

9. On the leading points of difference between the engines and carriages in use on railways in the United States and in Great Britain, and the reasons for any peculiarities in the American practice, with details of the cost of maintenance.

10. On the most suitable materials for, and the best mode of formation of, the surfaces of the streets of large towns.

11. On the construction of catch-water reservoirs in mountain districts for the supply of towns, for irrigation, or for manufacturing purposes.

12. Accounts of existing water-works, including the source of supply, a description of the different modes of collecting and filtering, the distribution throughout the streets of towns, and the general practical results.

13. On pumping machinery for raising water, both for high and low lifts.

14. On the drainage of towns and the ultimate disposal of town refuse.

15. On the employment of steam power in agriculture.

16. On the ventilation and warming of public buildings.

17. On the design and construction of gas-works, with a view to the manufacture of gas of high illuminating power; and on the most economical system of distribution of gas, and the best modes of illuminations in streets and buildings.

18. Critical observations on estuary tides.

19. On the construction of tidal or other dams, in a constant or variable depth of water; and on the use of wrought iron in their construction.

20. On the arrangement and construction of floating landing stages, for passenger and other traffic, with existing examples.

21. On the different systems of swing, lifting, and other opening bridges, with existing examples.

22. On the measure of resistance to bodies passing through water at high velocities.

23. On the results of the best modern practice in ocean steam navigation, having regard particularly to economy of working expenses, by superheating, surface condensing, great expansion, high pressure, etc.; and on the "life" and cost of maintenance of merchant steamships.

24. On ships of war, with regard to their armor, ordnance, mode of propulsion, and machinery.

25. On the measures to be adopted for protecting iron ships from corrosion.

26. On coal mining in deep workings, including machinery for dispensing with gunpowder in "getting" coal.

27. On the present systems of smelting iron ores, of the conversion of cast-iron into the malleable state, and of the manufacture of iron generally, comprising the distribution and arrangement of iron-works.

28. On machinery for rolling heavy rails, shafts, and bars of large sectional area, and for forging heavy masses of metal.

29. On steel, and its present position as regards production and application.

30. On the safe working strength of iron and steel, including the results of experiments on the elastic limit of long bars of iron, and on the rate of decay by rusting, etc., and under prolonged strains.

31. On machinery for washing lead ores.

32. On the present state of submarine telegraphy, and on the transmission of electrical signals through submarine cables.

THE GREATEST AMERICAN RAILWAY.—The Pennsylvania Railroad has at last effected the actual consolidation with it of its two main Western connecting routes. The Pittsburgh, Fort Wayne, and Chicago, and the Pittsburgh, Cincinnati, and St. Louis Roads thus become practically a part of the Pennsylvania Central, and over 1,000 miles of railway, stretching from the seaboard to the great cities of the Mississippi Valley, pass under the control of a single corporation. The nature of this gigantic combination, effected by the great Pennsylvania line while ours are busy feeing lawyers and procuring injunctions, may be better comprehended in the light of the fact that it brings under one management property valued at $280,000,000, and reaches for freight and passengers from Philadelphia to Chicago, Cincinnati, and St. Louis.—*N. Y. Tribune.*

EXCAVATING IN QUICKSAND.

SHEET PILING; PUDDLE WALLS; OBSTRUCTING WATER.

Condensed from a paper by Wm. J. McAlpine, C. E., before the American Society of Civil Engineers.

Description of Works.—In the autumn of 1866 an earthen dam was built across a small valley near the head of the Acushnet river, to form the storing reservoir of the New Bedford Waterworks. The dam was 600 feet long, 25 feet high, 20 feet wide on top, with slopes on each side of 2 to 1. The earth about the dam is the decomposed primary rocks, similar to that of the general coast range, being coarse and fine gravel and sand, with a little vegetable loam on the surface, and with no clay or almost none. Below the surface muck was a stratum of hard pan of irregular thickness from one to three feet, and beneath this was a bed of fine sand, which by subsidence and pressure was so hard as often to require to be picked before it could be removed with the shovel.

The earthen dam was exceedingly well built. There was a puddle wall of ample width in the middle, which was extended in all cases to the hard pan, and generally 4 to 6 feet below it, with a "toothed" bottom. The muck under the upper slope of the dam was removed to the hard pan, and in some cases the muck was also removed from beneath the lower slope. The puddle wall was made of the best materials that could be procured in the neighborhood, which was fine gravel, mixed with coarse and fine sand, and the loamy sand from the surface, all of which were incorporated together by the free use of a large quantity of water and by cutting with spades. The upper slope of the dam was protected by a well-made slope wall of very large-sized quarry stone. The reservoir or lake when full, covered about 200 acres, and the water was 20 feet deep at the dam. The gate house was built at the western end of the dam at the foot of the upper slope of the bank, and the waste culvert and conduit were extended from it entirely through the earthen dam. The foundations of the gate house and culvert were placed at the level of the lowest water in the river, which was about 3 feet lower than the surface of the swamp and were made by placing on the hard compact sand, a floor of large unhewn blocks of granite, with the edges and end joints hammered off to lines. The stones were laid on a bed of hydraulic cement mortar, and great care was taken to fill the vertical joints tight. The waste culvert was in the form of a segment of a circle of 8 feet chord, and 3 feet versed sine. The conduit was an oval of 3 and 4 feet diameters, made by 3 courses of brick. Its grade was 5 feet higher than that of the culvert, and it was supported on top of the latter from the gate house to near the middle of the bank, and then was curved to the right and was supported through the lower half of the embankment on a puddle wall. All this work was laid in excellent hydraulic mortar.

The lake was filled with water during the early summer of 1867, and remained full until February, 1868. The dam and the waste culvert were frequently examined during this period of 6 months. The dam itself was perfectly tight. A very small stream of water escaped at the lower end of the waste culvert, but this ran clear, and evidently came from the hill side. The workmen drank it, because of its purity and low temperature. The water in the lake at that time was highly colored, and at a comparatively high temperature. There were a few very small holes in the bottom stone and in the arch, where very cold clear water escaped almost in drops. The author first visited the work in June, 1867. The lake had not then been filled, but the water in the river had been shut back so as to be at a level 5 or 6 feet higher than the bottom of the gate well. A leak had occurred through its foundation (the stone pavement), which had brought up with the water considerable fine sand. A new floor was then being laid on the inside of the well, which completely stopped the leak at that place.

The Breach and its Causes.—About the middle of February, 1868, there occurred an exceedingly heavy fall of rain, and as there had been two months of previous heavy rains, and the ground was then frozen, the engineer apprehended that the water might rise too high in the lake. He therefore raised one of the gates at the gate house, giving an opening of 6 square feet under 20 feet head. Three days later he sent an intelligent man to close this gate. This person asserts positively that he shut the gate, but he adds that the water continued to flow out through the waste culvert in undiminished quantity, and it is therefore certain either that the rod attached to the gate was broken from it, and thus the gate was not closed, or that the leak in the gate well of the previous June had made a passage under the gate house, and had forced upward some of the pavement stones of the waste culvert.

Several intelligent persons were at the dam within 1 day of the time that the breach occurred, and did not observe anything wrong. No one witnessed the breach, which occurred 48 hours after the gate was supposed to have been closed, and swept out 100 feet in length of the embankment, and discharged probably within a few hours 300,000,000 of gallons of water. Fortunately the dense cedar forest which extended for half a mile below the dam, so much obstructed the flow of this large body of water as to prevent much damage on the river below. The rush of water at the dam undermined the waste culvert and lowered the pavement 2 or 3 feet, and also toppled over the gate chamber. The author visited the work the middle of May to determine upon the plans for the repairs of the dam and works. It was very important to discover, if possible, the causes which had produced the breach, but a sufficient number of facts had not been ascertained to determine these causes definitely, and it therefore became necessary to review all of those which *might* have produced the accident:

1. The stone pavement had been placed on a bed of quicksand, which although very hard and compact when dry and undisturbed, became a semi-fluid when saturated and subjected to disturbance. It was well bedded in hydraulic cement mortar, and the joints filled as close as possible, but it was practically impossible to make these joints all perfectly tight, and many of the openings between the stones, in places, were of considerable width. The discharge water passing through the culvert had a velocity of 10 feet per second, which was sufficient to force its way downward into any imperfect joint, and to rapidly wear away any portion of imperfect mortar until it reached the very fine sand on which the pavement rested; and this would be quickly removed by such a current of water, and cause 1 or more of the stones to settle, and then the current would rapidly extend its efforts under other stones, and soon cause the culvert to settle and break and leave the lake water free egress through the embankment. That the pavement had some such imperfect joints was shown by the leak which had occurred in June previously, and that the pavement was undermined as above hypothetically stated, by finding the stones at a level 2 or 3 feet lower than that at which they were originally laid.

2. The segmental form of the waste culvert arch produced a horizontal thrust upon the stones forming the foundation. These stones did not extend entirely across the foundation (transversely). That is, from 3 to 4 stones were used to make up the width of 12 feet. This thrust was produced by the weight of the stone arch and of a body of earth, which, in moist condition, would bring a weight of 40 tons per lineal foot on the arch, and to resist it was only the inertia of half a ton, the friction on the earth, and the resistance to the compression of moist or wet earth of less than 2 square feet area. These single stones may, therefore, have been forced into the earth horizontally, and thus joints opened to the attack of the current of water, or the arch stone may have slid upon the pavement, and in either case allowed the arch to fall and thus open a passage for the lake water through the embankment.

3. The conduit having an unequal support in passing through the embankment, may have become cracked at or near the place where it lost the support of the culvert masonry, thus admitting water into the embankment (which in this place had been made of fine sand), thus carrying it off.

4. The water from the lake under 20 feet head might have forced a small passage through the fine sand entirely below the base of the dam and of the foundation of the masonry, and gradually enlarging itself have finally produced the breach.

A consideration of all of the circumstances of the case led to the belief that the breach was caused by the first of the conditions above named, and that it was probably aided by the second. Nevertheless, it was regarded as prudent to provide in the new work as far as possible, against *all* of the causes which might have produced the disaster. The plans which were determined for the repairs were as follows:

Plans for Repairs.—1. To remove the quicksand across the breach, for the whole width of the base of the dam, as low as could be done without great expense, and replace it with fine gravel, mixed with a little loam (which was the best material which could be procured without hauling a dozen miles).

2. To place the waste culvert at a level 3 feet higher than in the original structure, so as to have its foundation resting on the greatest possible depth of gravel, and to build the culvert and conduit as 1 piece of masonry entirely through the bank.

3. To place the gate house about 40 feet above the upper toe of the dam, and extend a bank of gravel to cover the culvert and conduit from contact with the water in the lake.

4. To *place* within the main bank 2 rows of water-tight sheet-piling, which should extend as deep as possible into the quicksand below, and at least 20 feet horizontally into the old bank to the east of the breach, and at least as far into the side hill at the west, and to make a gravel puddle wall between these rows of piling, sunk as deep and as far into the banks at the ends as practicable.

5. To remove the slope wall from the face of the old bank and from the hill side for at least 60 feet horizontally, and face the bank anew with gravel of 3 feet thickness at top and 6 feet at bottom (at right angles to the slope).

To foot this facing at least 4 feet deep into the swamp, and in all cases to the stratum of hard pan, to which it should be carefully connected, and to uncover this stratum of hard pan for a circuit of 100 feet radius above the toe of the dam, examine its depth and make it (by adding gravel) a perfect lining over the whole bottom, and at its upper extremity to connect it with a cut-off of gravel sunk 4 feet deep into the underlying stratum of quicksand.

These precautions may at first thought seem to have been further extended than the case warranted, but a personal examination would soon convince an experienced engineer that it was really one of the worst cases that he is often required to meet. The disturbance in the bed of quicksand had changed it from a material of hard consistence to a semi-fluid, which flowed in from all directions and left the whole of the earth about the work porous or perhaps cavernous.

Sheet Piling.—Engineers often use sheet-piling by driving single planks or timbers, sometimes with tongues inserted and sometimes with a double course breaking or covering the joints. The author holds the opinion that in most cases such sheet-piling is not only useless, but is positively detrimental, and for a great many years he has used none but *placed* sheet-piling; that is, by excavating a trench to the requisite (or greatest practicable) depth, and placing in the bottom a timber, to which closely jointed plank are spiked (being also spiked to a similar timber at the top), and covered by a second course of jointed boards or plank. In other words, making a barrier perfectly water-tight against the head of water which will be brought against it. When the plank are thus placed, the trench is filled with fine gravel mixed with a little loam. It is impossible to drive plank singly and make a water-tight joint. The tongues or coverings are generally useless.

To prove this, let the greatest care be taken in driving some plank in a dry place. Then remove the earth and you will find the bottom joints of the piling open in both directions; and if tongues have been used, many of them will be found to have been split off at the bottom, and useless, and no covering plank can be put on, much less driven, which will make the joints water-tight. Such sheet-piling will not resist one foot head of water; and if water will pass through, then will the fine sand and loam or clay, and the whole piling becomes not only useless but deceiving to the engineer who has relied upon it; and who may from that cause lose his structure.

Angles to Obstruct Water.—But this is not all of the danger to be apprehended. Water will follow along a smooth surface for a great distance (horizontally and vertically), until it finds these open joints, through which it will freely pass, and then upon the opposite side, where it will continue to search for some escape under or around the structure. Water abhors angles, and by compelling it to make a sufficient number, its head can be entirely destroyed and prevent any damage. The interposition of these angles is often the weapon of defence that the engineer can avail of, against his worst enemy, and most useful ally—water. In placed sheet-piling you can provide at the bottom as many of these right angles as you deem necessary by means of the plank and timbers, which will generally give you seven angles, and these may be increased to any desired number.

Clay *vs.* Gravel Puddle.—Many young engineers fill their piling trenches with clay puddle. The author greatly prefers fine gravel, with a little loam mixed with it. The first coffer dam at the United States dry dock gave way, chiefly because it was filled with clay. The one built by the author withstood a great pressure because it was filled with gravel. Even paving stones were allowed to be put in the coffer dam, where they were surrounded by gravel. The particles of clay are cohesive, and a vein of water never so small, which finds a passage under or through clay, is continually wearing a larger opening. The particles of fine gravel, on the other hand, have no cohesion. Such a vein of water as has been mentioned, first washes out from the gravel the fine particles of sand, and the larger particles fall into the space, and these small stones first intercept the coarser sand and next the particles of loam, which are drifted in by the current of water, and thus the whole mass puddles itself better than the engineer could do with his own hands. The vacuities produced below, by this operation, are indicated by the settlement at the top, where more gravel, etc., can be added as is found necessary.

An embankment of gravel is comparatively safe, and becomes tighter every day. One of clay is much tighter at first, but is always liable to breakage, from the causes already mentioned. For the same reasons the piling trench should be filled with gravel, so that if any vein of water escapes through or below the sheet-piling, the weight of the gravel will crush down and fill up the vein, before it can enlarge itself enough to produce danger.

Difficulties to be Overcome.—The problem now before us was one of considerable difficulty. The sounding rods showed that the material to a depth of from 20 to 25 feet, was of the same character as that at and above the level of the river, viz.: a very fine sand, in fact a very troublesome quicksand. It was necessary to excavate a piling-trench in this semi-fluid to a depth of at least 15 feet. On the one side we had the river flowing through a wooden sluice and canals, and a heavy embankment of 25 feet height pressing down upon the bed of quicksand adjacent to the pit. On the other side was a steep side hill of 50 feet height pressing down upon a similar bed of quicksand. The excessive rains had filled the swamp and lands adjacent to the pit with water, to their utmost point of saturation. This quicksand was very pervious to water, and hence a large quantity of water might be anticipated to come into the pit during the operation, and if the work was protracted, the high banks on each side would be undermined and cave into the pit.

A steam engine of nominally 10-horse power and a pump, delivering 40 cubic feet of water per minute 13 feet high, were provided, but the power applied was $5\frac{1}{2}$ times the effect produced, which covered the friction of the machinery, increased greatly by the sand, and the loss of the water by loose buckets. The power of the engine was exhausted by the time the depth of 12 feet was reached.

Rules for Removing Quicksand.—There are 3 rules to be observed in excavating quicksand, and they are here stated concisely so as to impress the reader:

1. The water must be removed promptly and thoroughly.

2. The excavation must be made with the utmost despatch.

3. The material must not be disturbed after it begins to quake.

Now, these rules are almost never observed. It is almost impossible to make either engineers, foremen, or workmen follow them, and hence arise the chief difficulties and expense of removing quicksand. If they are strictly followed, the author guarantees that the difficulties and expense will be reduced one-half at least. Quicksand is defined to be a mixture of fine sand, with such a proportion of clay or loam as enables the mass to retain water within itself; and when in this condition, after it has been trampled upon for a short time, it begins to quake, so that it may also be called "quakesand." When it reaches this condition, if it is left quiescent for a few hours, the heavier particles of sand and clay settle down and expel the water, and the mass becomes again firm. If, on the other hand, it is further disturbed by the feet of the workmen, it becomes more and more fluid, additional material flows in from the sides, and no progress can be made in the excavation.

When the engineer has such a work in hand he should provide an ample pumping power. And here it may be noted that in most cases he will find that a power even 5 times as great as he anticipated will often in the end prove most economical. The pumps should be capable of lifting sand as well as water, and those are best which are not liable to be clogged. This is of more consequence than that they should work with a good "duty."

The author has found that in most cases sheet-piling protections around the pit to prevent the influx of sand are useless and often detrimental. If there is room to allow the excavation to take its natural slope, and the 3 rules are observed, the sheet-piling protection will be found unnecessary. Quicksand in a dry state may be excavated nearly vertical. These views will be illustrated by describing the operations at the place in question.

The Operations of Repairs.—The pit was commenced on top about 50 feet wide and 100 feet long. There were 30 laborers employed, who were arranged as follows: Six were kept constantly employed in removing and casting aside the sand from about and under the pump, to keep it far below the other parts of the excavation; 12 men were constantly employed in opening small ditches radiating out from the pump pit; 6 men were employed in excavating the ridges left between the radiating ditches, and as long as the latter were kept open these ridges offered perfectly dry digging. The remainder of the men were employed in casting further back the earth which was thrown out by the 6 men last mentioned. It will be seen that the actual removal of the earth was measured by that done by only 6 men out of 30, but these men had perfectly dry work.

All things being in readiness, the work of excavating was commenced early in the morning, and by mid-day the pit had been sunk in the lowest place to a depth of 12 feet, and then it appeared that the extreme power of the steam engine to remove the water had been reached, and it soon became impossible to keep open the radiating ditches, and consequently the earth between them became suffused, and soon after the whole of the lower portion was transformed from hard compact sand to a mass of semi-fluid material, quaking like jelly. The water began to "boil up" in many places in the bottom, and it was evident that no further progress in the excavation could at this time be made.

It was considered very important that the sheet-piling should be placed at a much greater depth than that to which the excavation had now been carried. To *drive* the plank to the desired depth, as has already been mentioned, would have resulted in open joints at the bottom. It was therefore determined to lessen the *number* of such joints by making up the plank in panels of 4 feet width, with joints matched and battened with 1-inch boards. One of these panels was placed in the proper line of the sheet-piling, and forced down by *pressure* nearly 5 feet deep. The non-fluid condition of the sand permitting this penetration, a second panel was forced down in the same manner, and with considerable trouble a tolerably close joint was made with the first panel, and further secured by a plank which was driven over the joint.

In this manner successive panels were driven in, until the whole width of the pit was covered by 2 rows of sheet-piling placed 15 feet apart. As the joints between the panels thus placed were of necessity nearly as open as in any other sheet-piling, it was determined to remove the water, and then the earth from *between* the rows of piling to the depth to which they had been forced, and then to batten and caulk up the joints on the inside.

Source of Water Determined by Temperature.—While the question of a new engine was being discussed, it became desirable to ascertain how much of the water which flowed into the pit, came from the leaky sluice and the canals, and how much from the natural water courses through the sand. The material being of so porous a character, it was impossible to determine this question merely from the directions in which these small streams came, but the author happening to have his pocket thermometer with him, he obtained the *temperature* of the water flowing into the pit from various quarters. The result was surprising. The temperature of the water in the sluice was 74°, and that of one set of the streams ranged from 71° to 73°, and of another set was from 56° to 61°, several of them flowing but a few feet from each other, with these widely differing temperatures.

Those of the higher degrees were evidently the leakages from the sluice-way and canal, and those of the lower temperature as evidently from deep-seated springs.

A rough, but sufficiently accurate gauge of each of the 20 small streams was made, from which it was ascertained that two-thirds of the water which came into the pit was leakage, the greater part of which could be prevented by a new sluice, and a better connection at the ends. With a diminution of more than one-half the quantity of inflowing water, the engine on hand would be of ample power to free the work from water, and enable us to get down to the requisite depth, and caulk the joints of the sheet-piling, and put in the puddle. This simple expedient, therefore, saved an expenditure of nearly $2,000.

The New Works.—The masonry of the new gate house, culvert, and conduit, is all laid in hydraulic cement mortar, and rests upon a foundation of timber, and 2 courses of plank. Concrete masonry is filled between the timbers, to take their place if they should ever decay, which, as they will always be submerged, will not soon occur.

There was another source of danger which had to be guarded against, viz., that the water would follow along the sides, top, or bottom of the masonry, through the whole width of the leak, and escaping at the lower side, again produce a leak. To prevent this, belt walls of masonry were built at each row of sheet-piling, and one still further toward the gate-house. These belt walls extend 3 feet beyond the outside lines of the masonry of the culvert and conduit on the bottom, on the side, and over the top, and are built up with the other masonry, thus forming a perfect cut-off to the water at each belt. The outer faces of these belts are "toothed," to produce angular obstructions to the water.

THE STRAINS IN GIRDERS.

METHOD OF DETERMINING THEM GEOMETRICALLY.

From the "Building News."

In 1856, Prof. Cullman, filling the chair of Civil Engineers at the Zurich Polytechnic School, published, under the name of "Graphical Statics," a geometrical mode of determining the stresses in structures, which deserves the greatest attention from practical engineers and architects. It is a process in which geometrical construction is substituted for complicated calculations; or, in other words, by which a great saving in time can be effected, together with a self-evident avoidance of liability to error. It will be seen that this process enables the architect or engineer to instantly note the effects of any alteration he may chance to make in his designs. As is seen one example we have chosen is that of the well-known case of a common Warren girder.

The basis of the method is simply that of the almost popularly known principle of the parallelogram of forces. It is well known that a force can be geometrically represented by a *straight* line running parallel to the given force, and denoting the amount of the force by its length. Of course a line *per se* cannot exactly denote a force, but if the course of the force or its direction from (say) right to left be also held to be indicated by the line, then all the required qualifications are given. Let us suppose, for instance, that we have a number of forces acting in a plane upon the same point. We then have, as indicated in the following diagram, to find the resultant of any number of given forces 1, 2, 3, 4, 5, acting upon 1 point, as indicated in Fig. 1:—Draw a polygon O *a b c d e* with its sides 1, 2, 3, 4, 5, parallel to the directions and equal to the magnitudes of the forces. These must be so arranged that if we indicate the courses of these forces in all the sides by arrows, all these arrows must point in the same course round the irregular polygon. The line R, closing this polygon by joining the origin O with the end *e*, represents the required resultant in direction and magnitude. Fig. 1.

This resultant is to be taken in a course opposite to the curve of the given forces. Any one of the diagonals in the polygon represents the resultant of all the forces

Fig. 1.

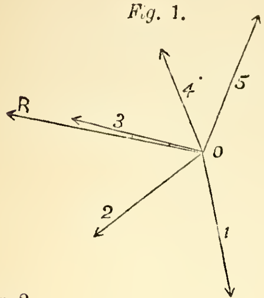


Fig. 2.

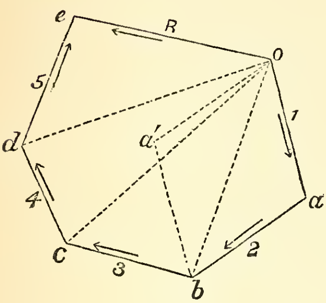


Fig. 3.

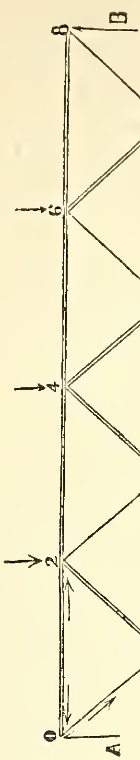
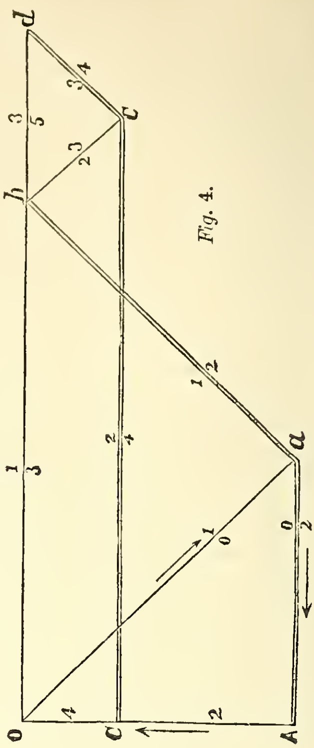


Fig. 4.



placed between the 2 points formed by that diagonal. This polygon may be termed the "polygon of forces," and it can be proved by successively combining the forces according to the principle of the parallelogram of forces.

If the polygon of any given number of forces, acting upon the same point, is closed, these forces will balance each other; and *vice versâ.* This is substantially the same proposition as that stated by Dr. Rankine, par. No. 53 of his "Applied Mechanics."

To determine 2 forces of given direction so that they may balance any number of known forces, all acting upon the same point, construct the polygon of the given forces and close it by 2 lines parallel to the directions of the given forces. These lines taken in the same direction round the polygon as the others represent the required forces. The second principle is a consequence of the first, and the third is easily proved by the second. With the assistance of these principles it is easy to ascertain the stresses on a Warren girder. To explain the process it will be sufficient to determine the stresses in a small girder constructed with only 4 divisions in the top beam, as shown in Fig. 3. There will be no difficulty in afterwards extending this to larger girders.

We will designate its parts by numbering the connecting points, and by calling each bar lying between them by the numbers at its 2 ends. We assume that the girder is loaded with 10 tons at each connecting point of the top; that is to say, at the points 2, 4, 6; while the resistances A and B of the supports act upon the extreme ends 0 and 8. As the load has been assumed to be uniformly distributed, each of these 2 resistances is equal to one-half the entire load of 30, or equal to 15 tons.

It is a necessary property of any structure that all the forces acting upon the same connecting point should be in equilibrium; and we employ this property to ascertain the stresses in the different bars. If all the forces acting upon such a point are known with the exception of

2, these 2 can be ascertained by means of the last principle stated. We begin at the point O, where the resistance A, equal to 15 tons, acts upwards, and we will proceed to determine the stresses in the bars 0 1 and 0 2, the directions of which are given. We draw the vertical line OA, Fig. 4, parallel to the force A in Fig. 3; and make it, by any scale, equal to 15 tons. The line A *a* is then drawn from A parallel to the horizontal bar *o* 2; and line O *a* parallel to the sloping bar *o* 1. These intersect one another at *a*. Therefore, the lines A *a* and O *a* respectively give the required amounts in tons of the stresses on the bars O 2 and O 1. They are of 15 tons and 21.2 tons. The curves of these forces only remain to be determined in order to know whether the bars have to sustain tension or compression. For this purpose, as we know the course of the force O A, which is indicated by an arrow, we have only to follow round the polygon of forces, which is in this case represented by the triangle A O *a* A, and to draw arrows in the directions in which we follow the sides O *a* and A *a*. By drawing other arrows in Fig. 3 parallel to the corresponding arrows in Fig. 4, we see that the stress in the bar 0 2 in Fig. 3 acts against the point 0; and that the bar 0 2 has consequently to undergo compression. Further, the force in 0 1 strives to pull the point 0 towards 1, testifying to a tensile stress. For the sake of clearness we shall henceforth indicate tension by a single and compression by a double line, both in the elevation of the Warren girder and in the polygon of forces. By this means the course of the forces can be seen both in the elevation and by comparing both figures also in the polygon of forces. We must observe that in the elevation the stress acts on an extremity of the bar in a sense opposite to that in the other.

We now come to the point 1. We have here, besides the last determined force in 0 1, the unknown stresses in 1 2 and 1 3. The stress in O 1 is given in Fig. 4 by the line 0 *a*, and its sense is now contrary to that indicated by the arrow. Proceeding as before, we draw O *b* parallel to 1 3 and *a b* parallel to 1 2, and cause them to intersect at *b*. The lines O *b* and *a b* give the stresses in 1 3 and 1 2 of 30 tons and 21.2 tons respectively. We determine the courses or senses of these stresses from the known sense of 0 1, following round the triangle *a* O *b a* in the direction given by the order of these 4 letters, and we find that the bar 1 3 is in tension and the bar 1 2 in compression.

In the points O and 1 only 1 known and 2 unknown forces were in action; but in the point 2, 3 known forces (the stresses in O 2 and 1 2 and the load of 10 tons) and the unknown stresses in the bars 2 3 and 2 4. To ascertain these, set off from A to C in the line A O the length representing 10 tons and C *c* and *b c* parallel to 2 4 and 2 3. These 2 lines then give the magnitudes of the required forces, because the sides of the polygon C A *a b c* C are parallel and equal to the forces acting on the point 2. They are also taken in the right sense, which is the reverse to the order of the letters C A *a b c* C. We find that 2 3 has to sustain a tension of 7.1 tons and 2 4 a compression of 35 tons.

The same proceeding is to be used at the point 3 4. The 2 known forces (1 3 and 2 3) are already placed together in the right curve in the diagram Fig. 4; they are represented by the lines *c b* O. The lines *c d* and O *d*, drawn parallel to the directions of the unknown stresses through C and O, meet each other in *d* and give the stresses in the bars 3 4 and 3 5, amounting to 7.1 tons and 40 tons respectively. The first is a compression, the second a tension bar. This gives us the strains up to the middle of the girder, and as the girder and the load are symmetrical we do not require to continue the diagram.

This Fig. 4 may be called the diagram of forces. The polygons for each connecting point in the first half of the girder are laid down in it, and, observing how they are combined, we find that the polygons for the preceding points give the forces always arranged as required for the construction of the polygon of forces for the following point. The whole diagram hence contains each force only once, while every line would have to be drawn twice if we construct a separate polygon of forces for each connecting point. What makes this diagram of forces so very useful is that there is a minimum number of lines to be drawn, and that the construction can be rapidly carried out without any liability to error.

SCIENTIFIC SCHOOLS IN THE UNITED STATES.—The Rensselaer Polytechnic Institute, Troy, N. Y.—Civil, mechanical, and topographical engineering and chemistry.

The Polytechnic College of Pennsylvania, Philadelphia.—Civil and mechanical engineering, chemistry, mining, agriculture, and architecture.

The Sheffield Scientific School, Yale College, New Haven.—Chemistry, natural science, engineering, agriculture, mechanic arts.

The Lawrence Scientific School, Harvard University, Cambridge, Mass.—Chemistry, zoölogy, geology, botany, comparative anatomy and physiology, mineralogy and engineering.

The Chandler Scientific School, Dartmouth College, Hanover, N. H.—Engineering, commerce, and general courses.

The University of Michigan, Ann Arbor, Michigan.—Civil engineering, general chemistry, mining, natural history, and general science.

The University of New York city, "Professional Department."—Engineering, architecture, analytical and practical chemistry.

The Washington University, St. Louis.—General science, and technical course.

The Cooper Union, New York city.—Free night-schools of science, of art, of design for women, and a polytechnic day-school.

Brown University, Providence.—Department of chemistry and engineering.

Massachusetts Institute of Technology, Boston.—Mechanical, civil and topographical engineering, practical chemistry, geology, mining, building, and architecture, and higher general sciences.

The School of Mines, of Columbia College, New York city.

Besides the above are the Scientific School of the New York Free Academy, New York city; the Collegiate and Engineering Institution, New York city; the Lehigh University, technical course; the University of Pennsylvania, technical course; the Worcester County Free Industrial Institute, Worcester, Mass.; the Cornell University, Ithaca, N. Y.; the University of the South, Suwanee, Tenn.; the Delaware Literary Institute and Engineering School, Franklin, N. Y., and the School of Mines in connection with Harvard College, Cambridge, Mass.

MENDING HYDRAULIC CYLINDERS.—An engineer in Berlin gives the following as a method of effectually stopping up a porous casting for a hydraulic press. The cylinder is to be heated over a charcoal fire to about 170° Fahr. It is then to be filled up with resin and suspended by a crane over the fire until the liquefied resin is seen sweating through on the outside. The excess of resin is then poured out and the cylinder allowed to cool, when the pores will be found completely stopped, and no water can possibly pass.

OIL CARS AND MOLASSES SHIPS.—As the use of barrels for transporting petroleum is giving place to tank cars, so the hogshead is to be superseded by the tank ship. The Atlantic Works at East Boston are to build an iron brig 350 tons, which will have compartments for transporting molasses in bulk. The saving of space and non-paying load will be very great, and this principle is likely to be carried farther.

LOCOMOTIVE ENGINEERS' CONVENTION.—The October meeting at Chicago was marked, says the "Chicago Railway Review," by good feeling, good sense, and temperateness. The subject of temperance, so vital to this particular calling, appears to have occupied the direct attention of the members, and is specially and hopefully referred to in the president's report.

UNITED STATES RAILWAY CONDUCTORS LIFE INSURANCE COMPANY.—The conductors of several important roads recently started an association thus named, at a meeting in Cincinnati. All conductors of good character may become members. The Secretary and Treasurer is to receive $100 per month, and all claims are to be referred to an executive committee of three.

PHOTOGRAPHING interiors by the aid of the magnesium light is pronounced a complete success. The Prussian photographic commission sent to Aden to obtain pictures of the late eclipse, returned by Egypt, and are obtaining fine copies of the great monuments of art there—among others the interiors of subterranean tombs.

PERMANENT WAY.

Rail Joints.—The introduction of steel rails has been accompanied in this country by an almost equally important and novel improvement—a rail joint. The chair, a mere seating for rail ends, is, let us hope, a feature of the old system that is all passing away. When a road has traffic enough to warrant the use of steel rails, it will pay to make them continuous by means of the fish joint, or its equivalent. The fish joint, after some twenty years of invention and experiment in rail-jointing, has held its own against all competitors. When plates and rails are both of steel, and shaped so that the wear can be taken up, the joint holds fast for years. The difficulty of keeping the nuts tight is now perfectly overcome by interposing a piece of leather, or a washer of rubber. Another important requirement of the fish joint is a well-shaped rail. It is a singular and fortunate circumstance that a rail well adapted to fishing is also well adapted to resisting deflection and wear. The old low pear-headed American rail —wasteful of material and rigid in detail, instead of stiff as a whole—might continue in use if it could be fish-jointed; fortunately it cannot be. The only objection raised against the fish joint for steel rails is that it requires holes to be made in the steel. Punching holes strains the steel and renders it liable to break —repeated experiments prove this. But the holes need not be punched. The loss of material in the fish-bolt hole—in the neutral axis—is of no practical account. If the holes are drilled, the material is not strained. The Pennsylvania Steel Works, and the Troy Steel Works, are introducing machinery to drill steel rails. Holes or nicks in the *flange* of a rail—especially a steel rail—are a hurtful loss of material, where the greatest and worst strain comes, and where loss of continuity can least be spared.

The new Reeves joint—a tight clamp upon the flanges of the rail—is getting into considerable use with steel. The long Reeves chair extending over two sleepers, is also much used with steel—as on the Hudson River road. This is more than a chair, but not tight enough on the flanges to make the track continuous. The authorities are divided as to the proper position for the fish-joint. On the Camden and Amboy, for instance, it is placed upon a sleeper, because, it is said, the joint is not as stiff as the rail, and needs this additional support. On the English roads, and the greater number of our own, the joint is placed between two sleepers to avoid the rigidity—the anvil action occuring when it is placed on a sleeper. If the joint did not *deflect*, the sleeper would do no more harm under it than under any part of the continuous rail. But as the simple fish-joint is not as stiff as the rail, and does yield, placing a chair and sleeper under it aggravates the effect of the blow of the wheel. The addition of the new Reeves joint—the tight clamp on the flanges—to the fish-plates, the whole being suspended between 2 sleepers, would make the rail practically continuous, and would avoid the evil of rigidity.

Earthwork and Bearing Surfaces.—"Engineering" says: Until we have much better earthworks, which, like the foundations of a house, can lie still and support in perfect rest almost any load brought upon them, we can never have mathematically perfect railways, and *until we have these we must tolerate that needless and extravagant increase of resistances* which attends any increase of speed above the lowest rate of motion, an increase from 10 pounds or so per ton at very slow speeds on a level, to 30 pounds or 40 pounds at 60 miles an hour. It is idle to say that we can have no better earthworks than we now have, or that the permanent way can rest no more quietly than it now does even on the best earthworks.

With the best earthwork and ballasting there must be abundant bearing surface of the rails on the sleepers, and of the sleepers on the ballast. Every permanent way engineer knows that the bearing surface is now insufficient to prevent the rails from notching upon the chairs, the chairs from bedding themselves in the sleepers, sometimes half way through, and the sleepers from churning the ballast. Mr. Fowler has found it necessary for the tremendous traffic of the Metropolitan (under ground) railway to abandon the double-headed rail, with its costly accessories of chairs, keys, and tree-nails, and to adopt a Vignoles (American) rail with a base nearly $6\frac{1}{2}$ inches wide, which is fastened to the sleepers by screw bolts. Thicker sleepers will permit the use of longer sleepers, without losing the available bearing now lost in consequence of the springing of sleepers only 5 inches thick. Sleepers 9 feet long, 10 inches wide, and 3 feet apart centres, give 13,200 square feet of bearing upon the ballast in a mile of single way. Sleepers 10 feet long, 12 inches wide, and 2 feet 3 inches apart centres, would give 23,466 square feet, or nearly twice as much.

Steel Rails.—But without steel rails there could have been no great improvement in the construction of permanent way. Steel has proved itself to be incomparably safer than iron; from 5 to 25 times as durable; to make a better and smoother way, offering less resistance to traction, and to permit of the use of still heavier engines—the very heaviest locomotives which the permanent way will bear without undue injury or wear being always the most economical.

The steel rails on trial on most of the leading American lines are showing remarkable endurance, but wear can be detected, and managers are comparing it with the wear of new iron, and calculating that although steel is very satisfactory, it can hardly come up to the alleged endurance of 20 to 1. They should not forget that the defect of iron is not in its abrasion, but in its lamination at the welds. When lamination—peeling once begins, the iron rail, however well it may have resisted *surface* wear, soon goes to pieces. But steel is subject to surface wear alone, it has no welds, and is as *sound* after half an inch has been ground off its tread as it was originally.

As to what is to become of old and worn steel rails, many people are unduly anxious. The "Chicago Railway Review" says: "They are useless after being used for rails." We are not aware that this product is in market, but we are aware that it will bring a much higher price than old iron rails, to be rolled down into small merchant bars and rods. The quality of these products will be better than that of equally good steel, cast in small ingots on purpose for small bars, as they will have had all the work necessary to reduce them from 10 or 12-inch ingots.

The Double-Headed Rail.—Says the "Mechanics' Magazine": The objections alleged against the double-headed rail are that, first, it necessitates the expense of chairs; and that, secondly, the turning of them, in which their chief merit lies, cannot be accomplished universally. If every rail could always be turned, so as really to do the duty of 2, then the increased amount of work got out of the rail would more than compensate for the expense of the chairs, and, *cæteris paribus*, it would prove more economical than the flanged description. To effect this result, two precautionary measures must be undertaken, the one to prevent the unevenesses and asperities which are produced upon that portion of the rail in contact with the chair; the other, to enable the upper head, after being worn, to bed evenly and steadily in the chairs. With the ordinary chair these conditions are not accomplished. The wooden keys which are employed to wedge the rail against the chair allow a small separation to exist under the varying circumstances occasioned by the influence of the weather. Consequently, the passage of a train produces a successive repetition of little shocks or concussions, which give rise, after a certain length of time, to a notching in the lower head of the rail which rests upon the chair. The "Mechanics' Magazine" then describes a new plan of interposing an elastic medium between the rail and the chair to prevent this under wear—a cushion of hard wood placed in a pocket in the chair. The use of steel of course decreases the rapidity of this wear in the chairs.

Other advantages of the double-headed rails are as follows: They are more readily removed and replaced than flat-footed rails, for as they are not directly fastened to the sleepers, all that is necessary is to knock away the keys and fastenings and lift them out of their chairs. Similarly, new sleepers are readily substituted for the worn-out ones, as sleepers and chairs can be removed together, while another, with its chairs fixed on, can be slipped in at once. The manufacture of the double-headed rail does not present so many difficulties as the flanged example, and it can probably be obtained cheaper in the market, especially when made of steel. The double-headed rail is better adapted for sharp curves, owing to the greater facility it possesses for being bent to the required radius. The flange of the American rail, by its comparative large breadth, bends with difficulty, and incurs a greater chance of being weakened and damaged by the operation. This is particularly the case with steel rails.

Iron Sleepers.—Our ways will never be really permanent so long as wood is employed in their construction. The expense of iron sleepers will, however, long prevent their introduction, except on lines of the heaviest traffic, and in countries where wood cannot be obtained much cheaper. The "Railway News" thus describes the various systems: All the varieties of iron permanent way may be reduced to one of the 3 following classes: Firstly, roads carried upon isolated supports, or "pot" sleepers; secondly, those supported by transverse bearers; and thirdly, those carried upon continuous or longitudinal supports. In Egypt, India, Brazil, and other distant countries, pot sleepers have answered well. A Belgian principle consists of a strong horizontal transverse sleeper of the double tee form, carrying 2 wooden blocks to serve as supports for the ordinary rail, of whatever shape it may be.

Three principal lines in France have afforded a fair trial to iron roads, and selected the Fraisans system, which gives a total weight per yard run, including rails and all fastenings, of a little over 2 cwt. The principle of Lecrimer, which in many respects greatly resembles that just quoted, has been laid down for 8 years on some of the Portuguese lines, and it is still doing good service. In Prussia the Hartwitch longitudinal road is employed to some extent. It consists of a pair of heavy contractor's rails, tied by iron transversals, which carry them and rest upon the ground, the flange of the rail having a breadth equal to half that of the height. The same principle has been adopted upon portions of the Lyons Railway, only the height of the rail is made equal to that of its base, which in this instance rests upon the ballast similarly to a Barlow or saddle rail. The system of Barlow is, in fact, identical with that of Bergeron, and so is the iron longitudinal plan that is soon to be practically tried in Austria.

At present it is certain that those iron permanent ways which are based upon the transverse principle have enjoyed more favor and likewise more success than those modelled after the longitudinal method. The desideratum to be insured in all rigid roads similar to iron ones is the imparting of some slight degree of elasticity, not as absolutely necessary for the safety of the road, but to diminish the enormous wear and tear that would be otherwise brought both upon the rails and the whole of the rolling stock.

Broken Rails.—A professional writer in the "New York Times," says: There is a comparatively inexpensive and wholly unobjectionable device for security against disaster by broken rails. We mention it here, not with the slightest expectation that it will be adopted on one mile of our forty thousand, but that the managers and legislators, who are maimed this winter by broken rails, may contemplate what it *might* have accomplished in their case, as they lie in splints all the weary nights.

A stick or plank of oak, as deep as the rail (say 4 inches), and 10 to 12 inches wide, fitted to the outside of the rail, bolted to the rail every 3 feet, and screwed down to every cross sleeper, would, in 9 cases out of 10, if not in all cases, hold a broken rail in place, and so prevent its throwing off the wheels. It would also prevent that other disaster, second only in frequency, but not in frightfulness, to broken rails, the spreading of the track. The timbers should break joints at a place where the rail has both vertical and lateral support on a sleeper. A wooden rail, heavy enough to support a wheel, and tough enough to endure any probable shock without breaking, is thus sandwiched with an iron or steel rail that will endure the wear and sustain the load, but which is liable to snap under a blow, just in proportion to its resistance to flexure and abrasion. Even steel, so remarkable in its wearing qualities, and so superior in strength and toughness, cannot be absolutely guaranteed against breaking. And the harder it is, the better it resists wear and deflection, the more liable is it to break. This is the law of iron and its alloys. Hence the combination of a tough wooden rail with a hard metal rail is in the greatest degree economical as well as safe.

It would be still safer to add also an inside plank of oak, so that the rail would be absolutely sandwiched between the two, and so prevented from displacement, although broken in pieces. This inner plank would, of course, be thinner, to allow room for the flanges of the wheels.

The longitudinal system, a rail spiked down to a continuous timber, instead of bridging cross-sleepers, although objectionable on economical grounds, is vastly safer against disaster from broken rails. A modification of this system, somewhat used in England, and destined, we think, to a more extended adoption, is called the sandwich system, and consists of a deep, thin rail, bolted between two heavy longitudinal sticks, which form the sleepers. A rail thus secured could be broken into bits a foot long without throwing off the train.

The continuous rail, made in two pieces, lying side by side, riveted together and breaking joints, was abandoned because the softness and structural unsoundness of iron unfitted it for the service. Why is not steel tried for continuous rails? One bar should be made extremely soft and tough to resist the blows and strains, the other hard to stand the abrasion.

But while the various plans that require reconstruction have that obstacle opposed to their introduction, the plan we first mentioned of one or more oak planks bolted to the sides of the rails, has, we think, no objectionable or impracticable features. The cost would be from $2,000 to $2,500 per mile. Its saving of damage is likely to be as much, not to speak of its constant and positive addition to the strength and durability of the permanent way, and to economical traction.

Conclusion.—"Engineering" closes the article hereinbefore quoted as follows: Railway engineers and railway companies must and will learn that upon the perfection of the way depends the highest working economy. After expending millions in Parliamentary struggles, millions for compensation, millions upon earthworks, colossal bridges and viaducts, tunnels by the mile, stations of the grandest dimensions and of superb architecture, and millions for costly locomotive and carriage stock, the question of a few thousand pounds more or less per mile for first-class permanent way is not one upon which true economy in working and in maintenance can be sacrificed. There are railways enough which have cost their £100,000 or more per mile, and plenty that have cost £50,000, whereas the difference between the cost of a really good as compared with an ordinary permanent way, the platform upon which all the functions of a railway are really discharged, need not exceed £3,000 per mile.

GEOLOGICAL Negatives.—Mr. James Thompson, of Glasgow, Scotland, has contrived a new method of producing photographic negatives of geological specimens. He saws from the stones thin slices containing fossil remains or other specimens; these when polished are so thin and transparent that they may be used as negatives for photographic printing upon the usual sensitive paper. Beautiful prints are thus obtained, having all the fidelity of nature itself. Large numbers of these fossil negatives have been prepared by Mr. Thompson, and he has undertaken to supply the British Museum with duplicates.

MR. N. SCOTT RUSSELL, son of the famous London ship-builder, is now engineer in charge of Messrs. Baird's works at St. Petersburg. The works produce marine and stationary engines and general machinery; also some 10,000 tons of rolled iron per annum. They employ 2,000 hands.

ZEUNER'S VALVE DIAGRAM.

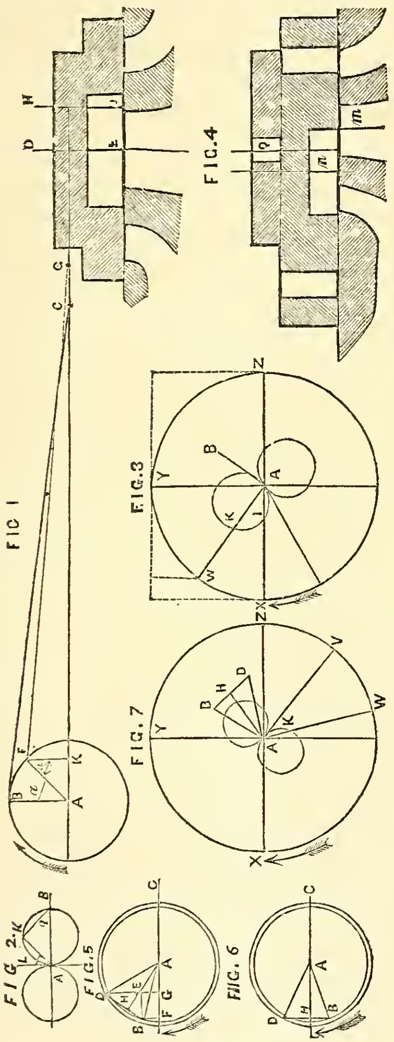
Translated from Zeitschrift des Vereines Deutscher Ingénieurs.

The great value of Zeuner's diagram for explaining the movements and construction of steam valves, induced the author to bring it within the limits of his lectures on mechanics, at the Polytechnic School at Saarb-in-Vien. But the want of the knowledge of the higher mathematics amongst those addressed, did not allow him to give the same investigation as is published by Professor Zeuner in his excellent book on valve gears; a more simple and elementary explanation was required, and this was obtained for the ordinary valve as well as for Meyer's expansion gear in a very simple manner. The author brought it before a meeting of the Society of Engineers at Saarb-in-Vien, and a favorable reception as well as the express wishes of the members encouraged him to bring it before the general public.

The chief point of Zeuner's method

consists, as is well known, in the determination of a simple figure, composed of straight lines and circles, by which the corresponding position of the valve, for any position of the crank or of the piston, may be easily ascertained.

In the following, the construction of the diagram is only confirmed in an elementary manner; as regards its prac-



tical application, the above-named book may be itself used.

A. *The diagram of the simple valve gear.*

Most valves are moved by eccentrics or cranks, and in order to simplify the expressions used, the latter may be supposed. This is correct, as an eccentric produces the same movement as a crank correspondingly fixed, and of which the radius is equal to the eccentricity of the eccentric. In Fig. 1, let

A=the centre of the driving axle.

AB=the valve crank (eccentric) in its central position.

BC=the eccentric rod.

CD=the valve rod as far as the valve centre D E.

If now the crank moves from the position A B into another one A F, the corresponding position, H J, of the centre of the valve is obtained by describing from the point, F, with the length of the eccentric rod, B C, as a radius, an arc, and from the point, G, where this arc crosses, A C, marking the length of the valve rod to the centre of the valve, equal G H. B C is in practice always very long in proportion to A B, and A C may be therefore, without committing a great error, taken as equal to B C, and F G equal K G; then A K is also equal to D H, if F K is perpendicular to A C, or the movement, D H, of the valve from its central position is equal to the base of the right-angled triangle, A K F, of which the hypotenuse is always equal to the crank radius, A B, and of which the acute angle, A F K, is equal to the angular movement α of the crank.

But all right-angled triangles with the same hypotenuse may be placed in a circle, of which this hypotenuse forms the diameter; constructing therefore a circle with the crank radius, A B, as a diameter (Fig. 2), drawing next the tangent, A L, and laying on it the angle, L A K$=\alpha$, from Fig. 1; the equality of the triangles A K B (Fig. 2) and A K F (Fig. 1) can very easily be proved.

The movement of the valve from its central position corresponding to any angular movement α of the crank, is thus very simply obtained, as the chord of the arc, A K (Fig. 2) by laying off the angle α from the tangents A L. Fig. 2 gives at first only the movement of the valve centre towards the right hand side, for the values of α between 0 and 180°; but by a symmetrical construction of the circle, A K B, upon the other side of the tangents, the corresponding movements of the valve towards the left hand side are obtained in a similar manner.

Now it will be easy, by means of the circles obtained in Fig. 2, and which may be called briefly valve circles, to construct a diagram, which will show for any position of the piston crank the corresponding position of the valve. In Fig. 3, let A X be the piston crank on the dead point, and A B the valve crank in the corresponding position, and X Y Z the crank pin circle. If the angle Y A X is made a right angle, and the angle X A V equal to B A Y, then the valve crank will be in the position A Y, *i.e.*, in its central position, when the piston crank A X stands in the position A V. Drawing now the valve circles, as constructed in Fig. 2, so that in Fig. 3 they touch the line A V in A; the corresponding movement of valve from its central position for any other position, A W, of the piston crank, will be equal to that part, A K, of the radius of the piston crank, which is also a chord of a valve circle; and it will be seen at once, that the valve crank, when the steam crank is in the position A W, has travelled from its central position through the same angle, V A W, through which the steam crank has travelled during its movement from A V to A W.

B. *Expansion gear with 2 valves.*

The valve gear, represented in Fig. 4, is one with an expansion and distribution valve. Let m be the centre of the exhaust port, n the centre of the distribution valve, and o that of the expansion valve. From what has been already said, it will be easy to determine for any position of the piston crank—the corresponding positions of the centre n, with regard to the centre m, and that of the centre o, with regard to the centre m; it is, however, of importance to ascertain in a similar manner the reciprocal positions of the centres n and o. Thus, in Fig. 5, let A B be the eccentric or crank for the distribution valve in any position, and A D that of the expansion valve in the corresponding position, whilst A C may represent the axes of the valve rods. If B F and D G are penpendicular to A C, then A F represents with sufficient exactness—according to what has been stated previously—the movement of the distribution valve from its central position, and A G that of the expansion valve, and it will be thus easily seen that F G represents the distance between the centres of the 2 valves. Drawing now also B E perpendicular to D G, then F G= B E, and the distance between the 2 valve centres is again given by the valve B E as the base of a rectangular triangle B E D, of which the hypotenuse is constantly equal to D B, or to the distance between the crank pins of the 2 valve cranks. If A H is drawn perpendicular to B D, the angle B D E of the rectangular triangle B E D will be equal to the angle H A F, for the sides of the 2 angles are perpendicular to each other. Supposing now the line A H to be fastened to the 2 valve cranks, and the latter to be rotating, the shape of the rectangular triangle, B E D, will be determined by the known hypotenuse, B, and the corresponding value of the angle, H A F. The shape of the figure is, as for example in Fig. 6, drawn for an angle H A F=0; the projection from B D upon A C is then *nil*, or the centres of the valves coincide.

It is now easy, in an analogous manner, to represent, as a chord of a circle whose diameter is B D, the movement of the valve circle for any value of the angle H A F. For if, in Fig. 7, A is the centre of the piston crank, and A X its position at the dead point, if next A B and A D are the corresponding positions of the cranks or eccentrics for the distribution and expansion valves, and if A H is perpendicular to B D, then suppose the axle to be turned back through the angle H A X, and A H will fall upon A X, or the valve centres will coincide, and the corresponding position, A V, of the steam crank will be found, when angle X A V is made equal to angle H A X.

Drawing now the two circles, of which the diameters are equal to B D, so that they touch A V in A; for any other position, A W of the crank, that part A K of it, which is situated as a chord in one of the circles, will represent the corresponding distance apart of the valve centres. The accuracy of this will be seen, if we consider that, while the crank passes through the angle V A W, the line A H removes at the same angle from A X.

SHODDY GOLD is made of 100 parts pure copper, 17 of pure tin, 6 of magnesia, 9 of tartar of commerce, 1.6 of unslacked lime, and 3.6 of sal-ammoniac.

COAL MINING.

VENTILATION—MINING WITHOUT GUNPOWDER—SAFEST METHOD OF WORKING.

Condensed from the inaugural address of Mr Elliot, President of the North of England Institute of Mining Engineers.

With regard to the duration of the coal supply in Great Britain, Mr. Elliot said: I have no hesitation in expressing my opinion that it depends in a great degree upon the scientific improvements we are able to make in our mode of ventilating the workings. It is probable that the ordinary means of ventilation—whether by furnace or fan—may be aided by a change in the force or agency employed for the purpose of haulage and other underground work. As an instance of my meaning, I may mention that the apparatus which I have introduced in South Wales, and which by means of compressed air used as a motive power instead of steam, draws trams and pumps water with complete success, is found to generate ice in an atmosphere which is naturally hot and oppressive. The mechanical usefulness of these new air-engines seems capable of indefinite extension; while, as their cooling properties form a collateral advantage arising out of their use, it is at least possible that they may prove valuable auxiliaries to the more regular means of ventilation in extending the security and promoting the healthfulness of our mines.

The difficulties of ventilation once surmounted, the extent of coal at our disposal is incalculably increased. The fields to be worked below the sea on our east and west coasts are in themselves enormous, and will be for all practical purposes as entirely within the reach of the mining engineer as the ordinary workings out of which coal is hewed. Geology indicates that in many districts the coal strata extends seaward 10 or 12 miles beyond the shore; and it is my firm belief that by sinking ventilating shafts in the German Ocean, the coal below it may be worked as safely and certainly as it is beneath where I am now standing. Nor do I recognize any difficulty in the transport of such coal. According to my estimates, it would neither be more costly nor more laborious than it has been in days gone by to convey coal the same distance after it was brought to the surface inland.

Mr. Elliot's next proposition aims at revolutionizing the system under which coal is worked. He says: It is simply that we should abolish the use of gunpowder in our mines, and by so doing reduce the number of deaths from colliery explosions to a minimum. For more than a quarter of a century I have steadily looked forward to this end; have upon all favorable occasions agitated the subject among my engineering friends; have tried divers experiments; and have watched and tested with earnest interest inventions which had the disuse of gunpowder for their aim. Nearly 20 years ago, while giving evidence in the House of Lords, I suggested that the Government should offer a premium to any one who succeeded in making such discovery. It should never be forgotten that the existing necessity for the use of gunpowder is the fruitful source of colliery accidents; once abolish it, and the need for naked lights is gone. Safety-lamps might be devised which the pitmen could not open. At present the phrase "safety-lamp" is a misnomer. No lamps yet invented are entirely safe. A series of experiments, tried several years ago, showed us that at a certain velocity the flame passed all the lamps in existence; and until it is possible to send our men into the pits with enclosed lights and cases which are immovable, we shall not have grappled with the difficulties arising out of the fire-damp and gas.

The substitution of mechanical means for blasting by gunpowder is, however, fraught with difficulty. Our early experiments were not successful; we endeavored to burst down the coal with quick-lime and other substances, but failed in every instance, owing to the slowness of the operation. I have tried, moreover, to force down the coal by hydraulic machinery, but failed also, through the water percolating into the coal and exhausting itself by that means. I have, however, the satisfaction of knowing that our labors have not been altogether lost, for their results having been sedulously made known among my younger engineering friends, they in their turn have brought their energies to bear upon the point, and with considerable success. I have recently seen 3 kinds of appliances for this purpose, some of which are being worked at this moment in my collieries in South Wales, and, according to the latest reports, working well. My conviction is, therefore, that mechanical means will very soon make the use of gunpowder unnecessary; that lights which it is possible to explode will, in consequence, be banished from our pits; that our coal will be produced in a far better condition, as well as at comparatively little risk to human life.

As a general rule, pits of a less depth than from 60 fathoms to 80 fathoms are almost free from gas; at from 80 fathoms to 180 fathoms deep, gas is most dangerously prevalent; after the last limit has been passed, the workings down even to 300 fathoms, again become comparatively pure. A feasible reason for this singular gradation is that, in the zone first named, the gas has a natural vent at the mouth of the pit, and by means of the various strata through which it can filter to the surface. At the middle zone, or point of greatest danger, the gas has not the same means of clearing itself, while that generated there is augmented by the gas ascending from the greater depths, and the aggregate amount stagnates, to the increased peril of those working in it. Another reason is, that the gas generated in coal at the lower depths is increased in heat, owing to the additional weight of the superincumbent strata. The heightened temperature causes it to expand and ascend, and so find its way to the middle distance, which becomes surcharged. I have found that in this zone (80 to 180 fathoms) a sudden fall of the barometer produces a greater increase of gas than in either of the others—another proof how much more it is charged.

In the zone nearest the surface the working of seams one above the other has not the same effect as in the other two. But by working seam over or under seam at the middle distance, and at the greatest depths of all, a wonderful improvement takes place in the condition of the coal. The lateral workings provide the gas the same opportunity of escaping as at the least dangerous depth. It finds its way through the strata from the opening out of the seams above and below, just as it does to the surface in the first zone. The result is that coal, which when it is first reached is soft and crumbly, becomes hard and firm, and workings which were originally surcharged with gas are made purer and more safe as the seams above and below them are displaced. At Monkwearmouth, Usworth, and other deep pits, the general improvement from this cause has been very marked. We here see that the principle on which many of our colliery leases are granted is erroneous. These contain stipulations that all upper seams shall be worked first. But the clauses, designed as they are to preserve the coal and avoid loss, defeat the object in view. To work seam under seam and over seam concurrently, is advantageous both to lessor and lessee; it insures a purer atmosphere underground and a better condition of coal, and therefore merits the advocacy of all interested in our coal-fields and the extent of their supply.

COMPOSITION OF STEEL.

Gruner in Annales des Mines and Berg und Hütten Zeitung.

Translated by John B. Pearse.

What is steel? This is a question which has of late been frequently discussed, while a satisfactory solution is rendered diffiult by conflicting definitions of the word steel, the distinctions of which are too often rather theoretical than practical.

Experience proves that pig and wrought-iron may be produced from any ore with great facility, and that the products vary in quality according to the impurities of the ores, and the methods of reduction, as the latter do not remove all impurities in equal proportion. These products may be soft or hard, cold or red-short, brittle or tough, but are called pig-iron or wrought-iron as the case may be. To all products which do not come under one or other of these heads the term steel may be justly applied. Pig or cast-iron is the raw product of the reduction of the ore, and may be hardened when chilled quickly. Wrought-iron includes all iron pure and impure, and made either directly from ore or by operating on pig-iron; wrought-iron is malleable cold and hot, but cannot be hardened. Steel occupies the middle position, and while it remains entirely malleable may be hardened. It is, then, difficult to say where the line shall be drawn, as the series of products is an unbroken one from the most graphitic impure pig-iron to the purest and softest wrought-iron. Cast-iron merges into steel, and becomes slightly malleable, and steel becomes soft and similar to iron in many of the products classed under the heads of puddle or simmer steel, etc.

These differences may be remarked as well in the chemical constitution of the respective materials. It is, however, difficult to determine the exact amount of each element present, as the quantity is so small proportionally to that of the iron. Experience shows, however, that the same foreign elements show themselves in the pig-iron, the steel, and the wrought-iron. We find that the same products, varying only in purity, may be prepared from any ore, and therefore consider it proper to take it for granted that these various forms of iron are due to the relative amounts of carbon and other elements present in them. It has long been known that all metals are materially affected by small amounts of foreign elements, and no exception to the rule is possible in the case of iron.

Copper is greatly affected by traces of oxygen, sulphur, or lead; and a few thousandths of a per cent. of iron reduce the ductility of both zinc and tin. Fremy has shown that a trace of bismuth or lead makes gold as brittle as antimony. It is further known that chrome, nickel, turgsten, etc., harden iron similarly to carbon.

The substances which are associated with iron are, however, more numerous than is generally believed. The following may be mentioned: Carbon, silicium, phosphorus, sulphur, arsenic, potassium, sodium, calcium, magnesium, aluminium, manganese, nickel, chrome, titanium, vanadium, copper, nitrogen, and sometimes cobalt, molybdanum, etc. It may be asserted with justice that pig-iron contains some portion of every element present in the ores from which it has been derived.

The presence of nitrogen has been shown to be without any influence on the formation of steel as Fremy supposed, and the quantity of the same in steel has been shown to be so small that its very presence has been reasonably doubted. Aluminium is present in all irons smelted from clay iron ores or any of the varieties of black band; these irons contain also calcium and magnesium. Some analyses render it probable that the silicium present in gray irons rich in manganese is probably chiefly combined with the latter; the probability of such a combination is made stronger by the results obtained by Brunner and Wöhler, who found that manganese may be readily alloyed with $\frac{1}{12}$ per cent. of silicium.

Gray iron often contains more than 10 per cent. of foreign constituents, the number of which is very great. This is especially the case when the iron is very graphitic and has been reduced at a great heat. Fresenius' analyses show that white iron (spiegeleisen) may contain nearly 18 per cent. of other elements, manganese and carbon with silicium being always in preponderance. These elements are reduced along with the iron even when the latter is produced at the lowest possible temperature, as is the case with a number of the Styrian white irons.

Elements present in the fluxes are reduced into the iron, as for instance calcium in considerable quantity when much lime is used with clayey ores. Therefore it may be stated as a general truth, that pig-iron contains some part of all substances present in the furnace at the time of its reduction.

With reference to the elimination of these substances, experience proves that only those elements may be entirely eliminated which possess at the same time a great affinity for oxygen and a weak affinity for iron. These are manganese, calcium, magnesium, etc. Deville has shown that aluminium is less readily ozidizable, and that it is present in some varieties of steel. The majority of the varieties of steel contain in addition, sulphur, phosphorus, silicium, and copper; some French steels contain also cobalt and nickel. Parry shows that the puddled steel made at Ebbwvale contains carbon, silicium, sulphur, phosphorus, and manganese, and Karsten proved long ago that the four former are contained in every variety of wrought-iron. The composition of steel and wrought-iron is then quite as complicated as that of pig-iron, the proportions only of the respective elements being different.

The element which takes precedence of all others in its influence on the properties of steel is carbon. The results of the investigation of many kinds of Swedish and Styrian Bessemer steel show the great influence of carbon on the respective hardness and elasticity. In Sweden, 9 sorts of Bessemer steel are distinguished (Boman), and numbered 1, 1½, 2, 2½, 3, 3½, 4, 4½, 5, beginning with the hardest. Analyses made at Silianfors give the corresponding percentages of carbon as in round numbers :

No.	1	1½	2	2½	3	3½	4	4½	5
	2	1.75	1.50	1.25	1	0.75	050	0.25	0.05

per cent. carbon, which percentages corresponded to fixed characters and varieties of the steel. The absolute worth of the steel depends also on the number and amount of injurious elements present. It is probable that steel made from English and French pig-irons should contain less carbon than Swedish or Styrian steel, in order to possess the same welding or hardening qualities.

Tunner gives the following assortment of Styrian steel: Nos. 1, 2, 3, 4, 5, 6, 7, with respectively 1.50, 1.25, 1.00, 0.75, 0.50, 0.25, 0.05 per cent. carbon. Tunner had estimated by practical tests the carbon content of the respective numbers of the assortment exhibited by the Heft Works at Paris, and stated them as follows : For Nos. 2, 3, 4, 5, 6, 7, Tunner stated respectively, 1.35, 1.15, 0.85, 0.72, 0.53, 0.11 per cent. of carbon, while analyses made at Heft showed that Nos. 3, 4, 5, 6, 7, contained respectively, 1.10—1, 0.85—0.75. 0.42, 0.25 per cent. of carbon.

A series of Neuberg bars exhibited at Paris, contained for Nos. 1, 2, 3, 4, 5, 6, 7, respectively, 1.58—1.38, 1.38—1.12—1.12—0.88, 0.88—0.62, 0.62—0.38, 0.38—0.15, 0.15—0.05 per cent. of carbon. These figures show that 0.25 per cent. of carbon suffice to change the steel of one grade into that of another. They fully corroborate the old theory, according to which the grade of steel is proportioned to the percentages of carbon, other circumstances being the same. The latter reservation is necessary as other substances besides carbon affect the hardness of steel, and the facility with which it may be welded. Nevertheless it is perfectly correct to state that the qualities of steel depend principally upon the percentage of carbon.

The classification of steel has been studied with care, especially that of Bessemer steel, in order to be able to supply all qualities suited to every industrial requirement. In the course of these experiments many interesting observations have been made, among which that of Vickers, that the toughness of steel decreases as soon as the percentage of carbon exceeds 1.25 per cent., is especially interesting.

These data considered collectively show that the iron and steel and pig-iron of commerce are similar compounds of iron and carbon, which always contain other elements ; further, that the qualities of the individual varieties depend chiefly upon their purity and the proportion of combined carbon, and finally that an unbroken series of products connects the softest iron, with the least carbon, with the different kinds of steel, and these in turn with pig-iron. In white iron and hardened steel all the carbon is combined, while some carbon is present in an isolated state, as graphite in gray iron and unhardened steel. The exceptions to these observations seem to be very few.

Caron has lately shown that hammering produces an effect on the kind of carbon present similar to that produced by hardening the steel, and therefore supposes that hardening facilitates the combination of the carbon with the iron. I should prefer to believe that the hammering as well as the hardening prevented the separation of two bodies already combined. It is evident from existing data, that both in the blast furnace and in the cementing process iron takes up carbon in proportion as the temperature has been high and long continued ; if, on the contrary, the temperature is reduced slowly some graphite separates. The molecules of soft bodies require a certain time for motion. If the body is suddenly cooled the carbon cannot isolate itself. In my opinion, hammering causes the same result, because it prevents the iron and the carbon from crystallizing, as it were, separately in cooling, but forces all parts with great power into and through each other. A proof of the want of harmony in the effects of hardening and hammering lies in the fact that hammering increases, while hardening decreases the specific gravity of steel.

CORLISS ENGINES.—One of 150 horse-power, recently started for the Meriden Britannia Company, saved in a week's trial 41.8 per cent. of coal over an engine of the old-fashioned kind, with a considerable increase of load. Such results are so common in the history of the Corliss engine, and coal is so costly in New England, that it is a little singular to find so many "old-fashioned" engines still building and running there.

PROGRESS OF THE METALLURGY OF IRON DURING THE LAST CENTURY.

Translated from Berg u Hüttenmännische Zeitung, by John B. Pearse.

Extract from a prize essay by R. F. Stalsberg of Kongsberg, Norway. Part relative to the blast furnace.

Smelting with Coke.—The devastation of whole forests occasioned by improvident use of wood without replanting, necessitated this step. The production of iron in England diminished on account of the scarcity of fuel by about 90 per cent. between 1612 and 1740. Dudley substituted coke for charcoal between the years 1620 and 1650, but was not successful on account of the opposition of other ironmasters; it was, therefore, left for Abr. Darby to bring coke into use between 1735 and 1740, whereby the iron trade received a powerful impetus. The use of coke did not spread so quickly on the continent of Europe, partly because wood was plentiful, and partly on account of the quality of the products. The introduction of coke had become general, however, before 1820, since which time the production of charcoal iron has almost entirely disappeared in Belgium, while in Prussia it does not amount to one-tenth of the iron produced; in Austria the greater part of the iron is made in charcoal furnaces, many of which also still exist in the United States, while they are the only variety in use in Scandinavia and Russia, and it is only recently that coke has been tried in Sweden.

Although the production became vastly larger, the quality of the iron suffered, principally from sulphur and silicium; but it has been found that with ordinary care a first-rate iron may be produced. A partial use of coke or anthracite along with charcoal yields a cheaper iron, the quality of which does not seem to be materially impaired.

Use of Hot Blast.—Forty years ago it was generally believed that the cold blast was the best on account of the greater quantity of air forced into the furnace in a given time. Neilson introduced the hot blast at the Calder Iron Works in 1830, and in 1835 there were no more cold blast furnaces at work in Scotland. On the continent its use became general, but for a while it fell into disrepute because the quality of the iron was made poorer, so that it had been almost abandoned again, especially in Belgium, before 1843. It was found, however, that the cause of the difficulty was not the elevation of the temperature of the blast, but the retention of the old methods of working and proportions of flux, etc. On this discovery its use became general, and the temperature of the blast has been steadily rising till in some places it now reaches 1,000° or more. The high temperature has been found to render the working of the furnace more regular, and to save a great deal of fuel. The reduction of quality by the larger percentage of silicium incident to the greater heat, may be almost obviated by a proper variation of the fluxes and ores. Experience has shown that high temperature in connection with proper fluxes reduces the amount of sulphur in iron, while the reduction of all phosphoric compounds in the ores, etc., is practically as complete with the cold as with the hot blast.

Use of Furnace Gases.—The French developed their use from 1809 to 1836, but the most material progress was made by Taber du Four at Wasseralfingen in Würtemberg, who applied or attempted to apply them to almost every use to which they have since been put, among others to that of puddling. For the latter and similar purposes the temperature produced by their combustion is insufficient. They are almost exclusively used for the production of steam and heating the blast. There have been many doubts as to the economy of their use, but these have been gradually dispelled by experience. There are many methods of closing the furnace top, the best of which allow the gases to collect over the top of the materials, and draw them out in the centre instead of on the sides, such are those of Coignt in France and Langen in Germany. It is probable that the difficulty experienced at several works on closing the furnace top to draw off the gases, and the consequent increased make of white iron, might have been due to other causes than the closing of the top. Wherever the gases are used they should be drawn out of the furnace by a chimney draught, which, however, should be no more powerful than is necessary to overcome the resistance offered by the apparatus to the free passage of gas.

Substitution of Wood and Coal for Charcoal and Coke.—Wood has been substituted for charcoal with entire success;

the cost of carriage is, however, greater than that for charcoal where both must be hauled. For common purposes the use of raw coal is advisible; when, however, good quality is desired, especially freedom from sulphur, it seems best to coke the coal. The advantages of the use of both wood and raw coal are chiefly that the yield in charcoal and coke respectively is increased, and that the volume of the resulting gases is greater while the heating powers of the same are more considerable. The use of raw materials cooled the furnaces at first considerably, and for some way down from the throat; this difficulty was overcome by the use of the hot blast, and so enlarging the upper parts of the furnace that they might correspond in capacity to the increased dimensions of a given weight of wood, and that where coal was used they might permit the free passage of the ascending gas. In England raw coal is the fuel most generally used ; on the continent, however, it is seldom used, and never without admixture of coke. Wood has been in several instances used entirely without charcoal, but as a rule air or kiln-dried wood is mixed with charcoal in various proportions. In some localities in Austria peat is substituted for charcoal, even to the extent of two-thirds of the whole amount, while in America anthracite is sometimes used with charcoal.

The economy resulting from the use of raw fuel is considerable, but the quality of the iron made with raw coal is often seriously injured. Iron made from wood is quite as good as that made from charcoal. There are some coals, however, which can be used raw in the furnace, though they do not yield good coke.

Increased Size and Changed Dimensions of the Furnace.—The small size of the furnaces in use early in the century was doubtless due to the use of charcoal and an inadequate pressure of blast. On the use of coke, etc., the furnaces were enlarged, but principally by increasing their height ; the old form, with narrow, perpendicular crucible, flat boshes and small throat, was long retained as the best construction. In 1820 the crucible was widened considerably in England and Sweden, and its sharp angle with the boshes cut away (1820–1830), while the throat was greatly widened, even up to three-fourths the diameter of the shaft at the top of the boshes. The propriety of the comparatively wide throat is now generally acknowledged. The general form of the shaft is either that of one cone inverted upon another, with more or less cylindrical space between them, or that of an ellipsoid. The application of cylindrical shafts has remained almost local, and the great widening of the throat proposed by Truran has met with no approval : the elliptical form proposed by Alger has not as yet given any very extraordinary results. Rachette combined the ideas of Truran and Alger in his ingenious furnace. This furnace is reported to work well in the Ural Mountains, but the only one built in Europe (for smelting iron) has not as yet been more economical of fuel or allowed a greater production than the old form. The experiments with these various forms are probably not yet ended.

Improved Roasting of the Ores.—Roasting in heaps has been generally superseded by that in variously constructed kilns. In Sweden and Styria the furnace gases are advantageously used to roast the ores. Comparative trials made at various works on the advantages of burnt over raw limestone have led to the use of burnt limestone. These improvements have increased the yield and economy of fuel, while they have greatly added to the certainty with which it is possible to work a furnace.

Perfection of Machinery and Apparatus.—Increased size has necessitated more powerful blast engines, some of which are of enormous size, and furnish wind at very high pressures. The increased width of throat made it necessary to perfect mechanical appliances for charging. These consist in general of a section of a cone inverted over the throat, with the small end down ; the opening may be closed either from below by means of a bell, which is lowered (Parry), or from above by means of a cylinder, which is raised (Langen) to allow the materials to fall into the furnace. These charging arrangements also serve to collect and draw off the gas, that of Parry indirectly, as it merely closes the throat, while that of Langen is so arranged that the gases are drawn directly from its centre.

Utilization of Cinder from Puddling and Heating Furnaces.—(Tap and flue cinder.) Large quantities of iron were yearly lost in these cinders, before they were re-smelted. They should be roasted to facilitate reduction, and should be smelted with a large percentage of lime. The iron made of them is usually very cold short, and is used to mix with better irons in the puddling furnace, and seldom for casting, to which purpose, however, it would be well fitted, on account of its percentage of phosphorus, as it would run thinly and yield sharp castings.

FREIGHT LOCOMOTIVES

Compiled from "Engineering" and "The Railway News."

The present problem for great railways is how to accommodate an enormous freight traffic economically, and also in combination with frequent passenger trains at high speed. To lay other lines for the convenience and safety of passenger traffic, as has been proposed, would be to still farther lose the use of permanent way, already too little worked to pay proportionate interest on its cost. And where is the money coming from to build the other lines?

The theory and the modern practice are in the direction of longer trains, and consequently heavier engines. On the Northern of France Railway, for instance, there are tank engines of 59 tons which haul trains of 45 laden coal trucks on gradients of 1 in 200. Long, heavy trains are worked at less cost per ton carried than light trains, and railway managers generally are making the trains as heavy as their engines can handle, and constantly increasing the weight of their engines. In short, if 1 locomotive can be made to do the work of 2, it is needless to say that an immense economy would be effected in the working of our railway system. If the total working expenses with 20 freight trains of 35 cars each were 75 cents per mile in each direction daily, it would probably be found that for 14 trains of 50 cars each they would not exceed $1, the total cost for all trains being $2.40 per mile in the former case, and $2.24 in the latter.

But will the permanent way stand this increased weight of engines? Steel rails have to a great extent rendered this practice feasible, but steel rails will wear out in time, and the strains of heavier engines, *as now constructed*, upon themselves, and the sleepers and ballast, are very great, and have, perhaps, reached their practicable limit. The purely locomotive engineer is not so apt to see these facts as is the civil engineer, and especially the permanent way engineer. The former looks upon the permanent way as a camel's back, fitted to bear any and all burdens, burdens which no final straw can break.

To insure economical maintenance of way, the *weight upon engine wheels must be diminished*, or at least not increased, if engines are made heavier. The permanent way must be twice as strong to bear 6 tons on a wheel as would be necessary for 3 tons—earthwork, ballasting, sleepers, chairs, and rails—everything, must be twice as strong. And so it must be if but 2 or 4 wheels of all that are in a train press with a force of 6 tons each, and the 100 or 200 others are loaded only to half that weight. The line must be made for the maximum, not for the average nor the minimum load per wheel. The wear or abrasion of the head of the rail is not, it is true, dependent merely (although it is to some extent) upon the maximum load per wheel, and probably 2 wheels loaded to 3 tons each will cause nearly as much superficial *wear* as 1 loaded to 6 tons, although they will knock the way to pieces to a far less extent. Another fault of the existing types of engines is that the weight per wheel but seldom approaches anything like equality on all the wheels. Of 6-coupled engines, the leading wheels may be loaded to 7 tons each, while the trailing wheels may bear only 5, although 6 on each of both would be preferable.

The only way to diminish the weight per wheel of a heavy engine is, necessarily, to increase the number of wheels. It is, then, naturally asked, Why not attach 2 engines to the train? Two engines, however, require 2 drivers and 2 firemen, and a good deal of care to start and work in concert. But, then, there is the plan of working 2 engines footplate to footplate, with but 1 driver, and possibly but 1 fireman. The objections to this plan have been frequently pointed out, and there is but 1 line, the Turin and Genoa, where it has ever been resorted to. The driver's attention, sufficiently occupied with 1 engine, is divided between 2 of every lever, handle, rod, or whatever else he ordinarily has to touch—2 regulators, reversing levers, brakes, steam gauges, glass gauges, dampers, and steam blowers in chimney, 2 sets of pumps, safety valves, cylinder cocks, blow-off cocks, and sand boxes—at least 24 distinct claims upon his attention, where, with any ordinary engine, he would have but 12.

The 59-ton engines on the Northern of France, before referred to, have 12 wheels and 4 cylinders, 2 to each group of 6-coupled wheels. But these distinct groups are not bogies, all the axles being parallel, although the first and last axles of each group have considerable end play. The wheel base, therefore, is nearly 20 ft. long, and the engines thus strain the way laterally, and are often breaking their axle boxes. In any case such engines, having, too, all, or nearly all, the complication of the double bogie engine, must work with considerable friction.

The defects of the modern freight engine are metaphorically depicted by "Engineering" as follows: The locomotive of 1868 is a monster which all good engineers should unite to destroy. He is the stalking horse of railway bankruptcy, the gaunt steed of railway ruin. We can remember the locomotive shortly after he was foaled, and when, as a colt, he beat the devil's tattoo with his little wheels—heels we mean—weighing not more than five tons on the hind pair; and he was a 4-footed locomotive then, and not a 6 or 8-footed nondescript as now. Bless his little boiler! He could, as he was then, ride on the footplate of the hard-mouthed stallions that tear over the rails now, and *they* would never feel it, although the race-course 'yclept "permanent way," might. But he has grown altogether too big, and he must either have more legs put under him or else be knocked on the head. There is a main pair of legs to every engine, through which it must exert all its strength on a pull. For a strong pull all the legs must pull together, and all must keep exact step with each other. This can only be secured by means of certain harness known as coupling rods; but when more than 6 legs at most are coupled, there is fretting and chafing. What with the difference in shoeing, and in the weight on each pair of legs, there is a constant tendency to get out of step, which only the coupling rods can restrain. When the beast has 8, 10, or 12 legs, as some of them have, coupling rods may be carried altogether too far. The weight is well distributed, no doubt—say to 4, or, at most, 5 tons on a hoof—but the coupling rods do almost more harm than good, and in turning Tattenham Corner, or, in other words, a sharp curve, the off heels are playing mischief with everything on that side. The fact is, very long-bellied horses, of the breed we are dealing with, will never ride well.

Dropping the metaphor, 8, 10, or 12-coupled engines, having, therefore, necessarily long wheel bases, tear the way to pieces and themselves too. And the system of engine building which requires a permanent way twice as strong as it is necessary for the paying load, including wagons, to be drawn, is, on its face, wholly wrong, and nothing but habit and an almost pagan veneration for the outward form of the locomotive as George Stephenson left it, can account for the long continuance of a practice so palpably vicious. With properly constructed engines the permanent way need not be made nearly so strong as now, or, if the present strength were retained, the wear and tear, upon the plainest principles of action and reaction, would be very sensibly diminished.

The double bogie engine of Mr. Fairlie appears to meet the modern requirements better than any scheme that has been put forward. The double bogie engine, originally made, in a somewhat different form, many years ago, at Seraing, in Belgium, had many defects in detail which condemned it. In Mr. Fairlie's engine there has been found no serious fault, except the general charge of complication. This engine has 12 wheels of 4 feet in diameter, arranged in two groups, each group independent of the other, and driven by a pair of cylinders 18 inches in diameter with 24-inch stroke. Each bogie has a wheel-base of 8 feet 6 inches, and this length is practically the rigid wheel-base of the engine. The total wheel-base is 32 feet 6 inches, and this gives great steadiness to the engine, whilst, as will be seen, it does not interfere with its flexibility. The boiler is carried upon a cradle or carrier frame, which is in turn supported on the two bogie frames. The fuel and water are carried on the engine itself, the necessity for a tender is dispensed with, and the whole weight carried is made available for adhesion or grip on the rails.

The bogies are free to swivel on their pins, and each engine can radiate independently of the other; so whilst passing round even an S curve, each bogie can accommodate itself to the direction of the curvature without in any way interfering with the action of the other. The boiler has 2 barrels, each 13 feet long by 4 feet in diameter, these barrels springing from a central fire-box casing 10 feet 6 inches long. The barrels contain 352 tubes, 2 inches in diameter inside, and the boiler has altogether a total heating surface of 2,550 square feet. The grate surface is 32 square feet. Both the regulator and the reversing gear are arranged to be worked from either side. The tractive power of the engines, with a cylinder pressure of 100 pounds to the square inch, is equal to 33,400 pounds, or equivalent to drawing a gross load of 390 tons up a gradient of 1 in 25, at a speed of 10 miles an hour. The great points in favor of the double bogie engine are these: it admits of at least twice (and that an equal) subdivision of weight per wheel attainable with an ordinary engine. If such an extreme subdivision of weight be not desired, then it permits of the construction of a heavier and more powerful engine, with a given weight per wheel. So long as it has less than twice the number of wheels of an ordinary engine, it admits of shorter individual wheel-bases, and, indeed, this will generally hold good even where 12 or 16 wheels are employed.

One of these engines has been at work for some time past on the Neath and Brecon Railway, and Captain Tyler, who reported upon its working, described its motion over new and sharply-curved portions of the line as being so free from violent motion and oscillation, as to suggest to him the idea of "sailing." The South Western of Ireland is about to make trial of these engines, and another trial is to be given to one on the Central Pacific Railway. The engine, which has been built by William Mason, at Taunton, will shortly be put where its merits will be well tested, and its results brought home to us. At the western extremity of the Central Pacific the line ascends from Sacramento, at the sea level, to the summit tunnel in the Sierra Nevada, or Nevada Mountains, the ascent in a distance of 105 miles being no less than 7,042 feet, and the average inclination, therefore, 1 in 67 for the whole distance, while for 6 miles there are gradients of 1 in 45½, or 116 feet per mile.

By another arrangement of Mr. Fairlie's, that of hauling the trucks or cars from a centre draw-bar, each end working on a swivel, the largest of goods trains may be made to follow the curves and windings of a railway, without that risk of being pulled off the line which too frequently occurs in the case of long trains. This arrangement will be referred to in another article.

Meanwhile "Engineering" calls for other designs of 50-ton engines, and thinks there will be no difficulty in making a 6-coupled, 20-inch cylinder engine, with 2 feet stroke, 5 feet wheels, boiler 4 feet 9 inches diameter, 300 tubes 2 inches by 12 feet, 30 feet area of fire-grate, and 1,800 feet of heating surface; tractive force 16,000 pounds. Such an engine would have but 8 tons on a wheel, if the weights were properly distributed.

WILLIAM H. TALCOTT.—It is with regret that we record the death of this gentleman, which occurred on the 8th of December, at his residence in Jersey City. For many years Mr. Talcott has been known as among the most eminent of the Civil Engineers of this country. On all matters connected with hydraulics, his long and successful experience has given to his opinions especial weight and influence. It is not within the limits of this brief notice to enumerate the many public works with which he has been connected. From the very beginning of his professional life he has commanded the esteem of all who knew him; and his excellent judgment, his keen analytical powers, and unwavering probity, had placed him in the highest ranks in the profession. His name will always be remembered by those who knew him as that of an accomplished engineer, and a most estimable, upright Christian gentleman.

ALGERNON ROBERTS.—The untimely death of Mr. Algernon Roberts, of Messrs. A. & P. Roberts, Pencoyd Iron Works, Philadelphia, will be widely and sincerely mourned. He was one of our active, energetic, working engineers and managers, as well as a useful citizen and a genial friend.

MACHINE TOOLS.—One of the best features of modern mechanical engineering is the increased weight and better fitting of machine tools ; not simply because the work they turn out is better done, but because it is done more cheaply. For instance, a light planer can neither take a heavy cut nor a true one. When work leaves a tool, it should be finished —subsequent hand-scraping and draw-filing are neither beneficial nor economical. A planer can hardly be too heavy.

Another feature of modern practice is the use of special tools that can do one thing rapidly and truly, instead of convertible tools that can do anything. Versatility is not to be condemned, but in the extensive and regular reproduction of a given product, the sphere of the Jack-at-all-trades is limited.

Still another and a novel feature of modern tool-building is the devotion of the leading builders to various specialties —the 2 Philadelphia shops, for instance, that are known wherever good machine tools are appreciated. Although they are not relaxing their efforts in the production of miscellaneous tools, Bement & Dougherty make a specialty of Upright and Horizontal Boring Machines, Shaping Machines, Punching and Shearing Machines, Cotter Drills, and Steam Hammers. Their Boring Machine for the Boston Navy Yard, lately illustrated in various magazines, swings no less than 24 feet by the shifting of the uprights, and 12 feet ordinarily. Another machine from these patterns is constructing for the Washington Navy Yard. We notice at these works a Shaping Machine 20 feet long, with double travelling heads, for dressing out locomotive frames ; also a Pulley Turning Machine, to turn 2 at once, with round or straight faces. Among the Steam Hammers, the 250, 400, 600, and 1,000 pound sizes, for smith shops, appear to be thoroughly built and well adapted to miscellaneous work. The frame, slide, cylinder, and valve-seat or chest (rotary slide valve), are cast in 1 piece ; the anvil is independent. A considerable improvement in planers consists in casting side projections on the bed—widening it out—for straight vertical uprights, instead of bending in the uprights at the bottom ; this obviously stiffens the machine. Mr. Bement has overhauled the 40-inch lathe, making a very powerful, accurate, and highly adjustable machine. The live head is much lengthened, to give wider cones and heavier belts. A screw feed, for screw-cutting, is placed inside the bed, and is used for that purpose alone. It is reversed by clutches in the lathe head, instead of reversing overhead. Another rack feed is placed outside as usual. The lathe has an improved adjustable rest, supported on a heavy screw, to adjust the height of the tool ; also a facing-feed on the rest.

Among the specialties of William Sellers & Co. are Steam Hammers, in which their success has been remarkable, and is elsewhere referred to.

A NOVEL SQUEEZER.—In several of the iron mills where the Sellers hammer is employed, puddle balls are squeezed by being placed on the anvil and subjected to the powerful pressure of steam admitted above the piston. The squeezing saves much metal which would fly off under the *blow* of the hammer, or which would be crumbled off in the rotary squeezer. When the ball is compacted by pressure, it is patted and then hammered. This is the practice in making puddled steel.

The manufacture of the Morrison hammer, improved by Sellers, is a specialty of William Sellers & Co.'s business. The demand for Steam Hammers of all sizes, and especially of the smaller sizes for railroad and smith shops, is very largely increasing in this country, and this is a hopeful fact for better work and economical production.

THE SIEMENS' MARTEN PROCESS has been successfully started at the Trenton Iron Works, under the superintendence of Mr. Frederick J. Slade. Commissioned by several American steel and iron manufacturers to make a report on the state of the art in Europe, Mr. Slade devoted much time to these investigations, and especially to the study of the various new steel processes ; he also made a valuable contribution to the able report of Mr. A. S. Hewitt, United States Commissioner at the Paris Exposition. Under these auspices, we may look for the rapid development of this new and important manufacture.

SHIPS OF WAR.

THE MONITOR AND THE CASEMATE SYSTEMS COMPARED.

Abstract from various articles in "Engineering."

The advantages of the turret ship are these:

1. Having no masts, and having its guns and much of its armor further inboard, it rolls less than the broadside ship.
2. Its gun ports, being further inboard, would not roll under water, where those of a broadside ship, at the same angle of inclination, would do so.
3. For the same reason, the guns rise and fall through a less arc, and vertical aim can thus be better taken when firing in a sea way.
4. All its guns can be brought to bear on either beam, as well as a portion of them (where there are two or more turrets) on each beam.
5. The training of the guns is performed independently of the gunners, and their attention in loading, running out, aiming, and firing, is thus less interfered with than where the training is performed by hand and within the battery.
6. The guns can be trained nearly through the whole circle, upon an enemy manœuvring, and without turning the ship.
7. The turret ship can fight "end on," with the gun or guns of one turret, and nearly "end on" with the guns of all its turrets.

The advantages of the broadside system are:

1. They can carry masts and sails where the others, with their low freeboards, cannot safely do so. A ship with a high freeboard will roll through an angle at which a ship with a low freeboard would capsize, from the weight of water on one side of the deck. Thus the broadside ship may economize coal by setting sail where the turret ship has no sails.
2. Broadside ships in which men are exercised, messed, and berthed above the water line, are more habitable, healthful, and better lighted and ventilated than turret ships can be while cruising. Artificial ventilation may go far, but open-air exercise at sea is impossible.
3. The ship with a high freeboard carries its guns higher out of water.

It is only 8 years since 4½-inch plates would resist the best ordnance; now shot and shells are thrown by 50 to 100 pounds of powder through 5 and 6-inch plates, and the Whitworth flat-fronted projectiles penetrate even below water. And still heavier armor will soon be demanded to keep pace with artillery.

These are the respective advantages admitted, and the conditions required, but another important question is in dispute:

The partisans of turrets also claim that turret ships of a given displacement can carry thicker armor than broadsides; that, exposing a smaller surface to the enemy's fire, they are less likely to be hit, and that they can carry and work heavier guns. But when these alleged advantages are examined, they will be found to be to a great extent illusory.

It is easy to see that ships with 2 or more turrets—the Royal Sovereign has 5 and Admiral Halsted proposes 7—can carry very little more armor, with the ports the same height from the water, than broadside ships carrying the same number of guns. Although showing but little freeboard, the height of the armored side of the turret ship is much more than shows. The armor must go well down below water to provide for rise as the coal is burned out—a rise of 2 feet in a ship 300 by 50 feet for 500 tons of coal.

Supposing the *side* armor of the turret ship to be transferred bodily to the broadside ship. Then let us see how much more of the broadside ship the turrot armor would cover. Whatever the thickness and height of the turret, each one of them (25 to 26 feet diam.) presents 80 lineal feet for the protection of 2 guns, 160 feet (2 turrets) for 4 guns, and 240 feet (3 turrets) for 6 guns. A broadside ship 50 feet wide, with ports 20 feet apart, would enclose 4 guns at the ends and sides with 180 lineal feet of armor, and 6 guns with 220 feet. As the number of turrets is increased, so is the advantage of the casemated ship.

This comparison supposes the same height of sides; but even then the casemated ship is a high ship, and presents all the advantages of height above water, as far as the casemate extends.

The point, therefore, is not that one system presents more surface for protection than the other, but how far it is best to increase the height of armor in order to secure the advantage of a high side. The Koenig Wilhelm, clad with 2,800 tons, is regarded a good design. To add 7 feet to her height of armor, a foot thick all round, would increase the weight only some 900 tons. But it is the central battery only that requires protection for this additional height, and a battery of 100 by 50 feet, mounting 8 of the largest guns, increased 7 feet in height and a foot thick all round, would add but 450 tons weight of armor. The riddling of the unprotected high sides fore and aft the battery would be no serious matter.

Less surface presented to the enemy's fire is an advantage claimed for the turret system. But turrets always present half their diameter—a well-defined mark. Admiral Dahlgren reports that 8 monitors were hit 1,030 times while firing 3,587 shot. A broadside ship may be laid at a considerable angle of obliquity to the enemy's fire. The port holes exposed, and the use of port-stoppers, are the same for both systems.

Another claim for turrets is that only in them can the heaviest guns be worked. The same thing was said once of the 12½-ton gun, now worked in broadside. The Dunderberg works 18-ton guns in broadside. All that a turntable or a revolving turret can do is to train the gun; loading, elevation, running out and firing, have to be done by the same means in both cases. And in case of the revolving turret, some 125 tons of armor has to be revolved as well as the gun.

As to rolling: The monitors have their side armor built out over broad shelves projecting from the hull, and these act like bilge keels, or really, and more effectually, as side keels. These are equally applicable to broadside ships, and would lessen their rolling, while they would also lessen their speed, and we are not to forget that such a thing as a fast monitor never floated. Side projections, like the "guards" or extended sponsons of the American coasting steamers, or like even the paddle-boxes and sponsons of paddle steamers, greatly lessen rolling.

Again, although a war ship should be primarily perfect fighting machine, it may never have a chance to fight, but it must be the home of hundreds of officers and men for years.

The great advantage of the turret ship —facility of manœuvre—may be to a considerable extent obtained in the broadside ship by the use of twin screws.

But why not adopt Admiral Halsted's plan of mounting, say a couple of turrets on a broadside ship? The side plating of a 26 feet turret 7 feet high, and made of 15 inches solid iron, weighs 150 tons. With two of the heaviest guns now in use, with roof, central spindle revolving gear, and turret engines, the weight would be, say 300 tons. Two such turrets would thus weigh 600 tons, or about one-eighth of the displacement of a moderate-sized iron-clad—less than one-sixteenth that of the Northumberland. Yet consider for a moment what a ship Ericsson designed and built—the Dictator, to carry but 2 guns in a single 24 feet turret, 9 feet high, and 15 inches thick. That vessel is 314 feet long, 50 feet beam, draws 21 feet water, has a tonnage of 3,000, and, with no masts, a displacement of probably 5,000 tons. The engines, with 100-inch cylinders and 4 feet stroke, are to work up to 4,500 indicated horse power, and the boilers have far more grate area and heating surface than any vessel in the English navy. Now, when so much in the way of hull and engine power is provided in order to mount a single turret weighing in all, perhaps, 300 tons, why not carry the size of hull just far enough to secure the great advantages of the broadside system; and then, if thought best, retain the turret or turrets, placing them just above? Masts might or might not be retained; but such a ship would carry more gun power for its weight and cost, and be more powerful for destruction than any turret ship ever designed for the same speed and the same thickness of armor.

In conclusion, while admitting with respect to the strictly turret ships, all the advantages they really possess, it is impossible to deny that they should never, in the forms in which Ericsson and Coles have made them, enter into the navy *in any other capacity than as ships for coast and harbor defence.* If they are to have high freeboards, and to be masted and rigged, their turrets will be correspondingly high, and will thus increase the unsteadiness in a seaway. But thus improved, they would take a much better position in a comparison with broadside ships than they now do, and there would be good but not urgent reasons for their incorporation into the navy.

MARINE ENGINE IMPROVEMENT.

Compiled from "Engineering."

The marine engine in its present most advanced form is a splendid triumph of practical science and mechanical skill; but most middle-aged engineers can remember when, nearly 30 years ago, they thought the same of the clumsy contrivances, now long since obsolete, which then churned through the water, driving ugly hulls at 8 knots an hour. The simplest, lightest, and most economical marine engine of A. D. 1868, is still a complicated, heavy, costly affair, which, none can deny, needs a vast deal of improvement, if we can only find the means of improving it.

The theoretical advantages of high pressure steam, even up to 500 pounds or 1,000 pounds per square inch, and those of extended superheating, and of the utmost permissible degree of expansion, have been explained and insisted upon in innumerable pages of mechanical literature; and, still more ably and urgently, by the many apostles of an improved marine engine practice, who have passed or are now passing away. To what we may attain in the future, none can now pretend to say; but while it is undeniable that the principle of very high pressure superheated steam, with high piston speed and a high degree of expansion, is right, the cleverest engineers have only approached its advantages at a great distance in practice. No engineer need be told the reasons why, for they are known to all. At sea it would seem that, even with surface condensation, we are never to have pressures much above 50 pounds, although it is encouraging to hear so clever and so successful a marine engineer as Mr. John Elder, of Glasgow, who has succeeded with 50 pounds, expressing himself confident of attaining, with the same comparative success, a pressure very much greater yet. It is encouraging to find other engineers doing very well at a six-fold rate of expansion of 30 pounds superheated steam, in steam jacketted cylinders, and encouraging to know that Messrs. Penn's, Messrs. Maudslay's, and Messrs. Napier's very largest engines, are frequently run on trial, and for some hours together, at a piston speed of from 500 feet to 600 feet per minute.

The whole question of high pressure, say 50 pounds or 100 pounds at sea, turns upon that of surface condensation; and it is undeniable, that so far certain difficulties attending the use of surface condensers have rendered it necessary to keep to pressures at which sea water might, upon occasion, be employed in the same boilers, the vacuum being then maintained by means of an injection condenser, although the air-pumps, which are sufficiently large for a surface condenser, are altogether too small to pump out injection water. It is enough to say that whenever the long known difficulties—such as the furring of the condenser tubes, the accumulation of oil, acidulated or otherwise, in the boilers, or the corrosion of the boilers themselves—are once and finally overcome, there is nothing to prevent the regular use of 100 pound or 150 pound steam pressure at sea, any more than in locomotives upon land.

With injection condensers only a given amount of water is required for condensation, and to give more only needlessly lowers the temperature of the feed water, besides throwing additional work upon the air-pump, without obtaining any real improvement of the vacuum. But with a surface condenser the case is very different. With a moderate quantity of cooling water outside the tubes, a relatively large amount of tubular surface is necessary, inasmuch as the temperature of water rises so rapidly that it soon becomes nearly ineffective for the purposes of condensation, especially if the water be pumped from the Gulf Stream, the Red Sea, or any other warm source of supply. Some engineers maintain that it requires about as much cooling surface to get the heat out of the steam as it required of heating surface to get it in. The usual proportion of the former to the latter is about as 2 to 3 or 3 to 4. In any case the quantities to be dealt with are large. A pair of engines working to, say 2,000 indicated horse power, would, in moderately fair practice, require every hour the quantity of steam that would be evaporated from 900 cubic feet of water, or 15 cubic feet per minute. To condense this by injection, with the water at about 60°, would require 350 cubic feet, or 10 tons of water per minute. This would flow in from the sea; but its momentum being extinguished in the rose of the injection pipe, it would require to be lifted out again to the sea level, perhaps 10 feet or 15 feet, or even more; the work, exclusive of all losses, from friction, etc., thus amounting to from 7 to 11 or 12 horse power. Were the same quantity of water pumped through a surface condenser, there would be no loss of power (disregarding that from friction, bends, etc.) beyond that due to the head which would maintain the required rate of flow. If the 350 cubic feet per minute, or say 6 cubic feet per second, were to be passed through a net waterway of even 1 square foot, it would move at the rate of but 6 lineal feet per second, corresponding practically to a head of rather more than one foot. But much more than the ordinary amount of injection water is required with surface condensers. Yet on ship board, with the surface condenser 10 feet or 15 feet below the water line, 10 or 15 times the ordinary amount of injection water may be sent through without any real loss of power as compared with lifting out the injection water by the air-pump. In dealing with, say 3,500 cubic feet of water per minute (100 tons, or nearly 22,000 gallons of sea water), only centrifugal pumps would be reckoned admissible. No such large quantity is required in the case we have supposed, nor could any surface condenser adapted to engines of 2,000 indicated horse power well pass such a quantity unless the water ways between the tubes were needlessly large. Yet it is as well to remember the advantage which a large volume of condensing water affords, viz., that it renders a less extent of condensing surface necessary. The more water the less surface, the less total bulk of condenser, and the less cost.

Could marine engines be run twice as fast, they would require to be but half as heavy. Then why not run them faster? Because they would wear out two rapidly; the rubbing surfaces might heat, in spite of all lubrication—seize, and all would go to wreck together. This is exactly what would have been said, 20 years or so ago, of an attempt to run short stroke (4 feet) screw engines at 60 revolutions per minute, yet Penn's engines of that stroke, in the Bellerophon, have been run at 75 revolutions, and so far from breaking down are as good as new. Mr. Stirling's fine express locomotives, which we illustrated last week, running at 45 miles an hour, measure off 720 feet of piston per minute by the hour, and give no trouble. And were railways safe at still higher speeds, say 60 miles continuously, these engines would as easily (as they often now do for a few minutes) measure off from 960 feet to 1,000 feet per minute, by the hour together. Why should not marine engines do the same? Is it that there is not room for a 5-feet stroke, with a 10-feet connecting rod, and that 100 revolutions per minute are not required for the screw? If these are not the reasons what are they? It is certain that when we give up cast-iron pistons, of heaven knows how many tons' weight, when we employ hollow steel piston rods, when we abandon the ugly round connecting rods and adopt steel, channelled at the sides, thus I (or, if made to work through water, upon wood bearings as hereinafter suggested, they may be made of double edged sword section), when we adopt steel cross heads and bore out the axis of the crank pins and throws, we shall be enabled to run much quicker without jar or danger of heating. Lightness, good workmanship, and large bearing surfaces are all that is required to permit of the highest speeds.

Why should the stern bearing have the whole benefit of wood linings, the invention of which raised the screw engine and screw propeller from the depths of doubtful expediency to the summit of success? Silver linings—even they may be said to have been to the dark cloud which for so many years hung over the cause of screw propulsion. All the screw shaft bearings, including the thrust bearing, might be packed like the stern tube, with lignumvitæ, and they, with the shaft, might be enclosed in a plate iron trunk filled with water for 2 or 3 inches all around the shaft, and thus the bearings might go for months, if not for years, without being once looked at, and without the possibility of heating. And even the main bearings and eccentric hoops might be wood lined and worked in water.

As to the practice of various countries, "Engineering" concludes that the Paris exposition contained no better designed or better built marine engines than those by English builders, and instances an engine by Penn, weighing only 75 tons, but capable of 2,100 indicated horse power; also that some of the French designed engines of the Compagnie Générale Transatlantique, running to New York, had to be removed from the ships. It speaks well of the American beam engine for commercial purposes, on inland and outside waters. This type is of course unsuited to war service. It hopes that we Americans may long enjoy the monopoly of Mr. Isherwood's types of naval engines.

There is very little hope of improvement, this authority further concludes, from the use of the water jet propeller, or from the employment of liquid fuel at its present price.

SIEMENS' NEW PUDDLING PROCESS AND PLANT.

FACTS AND THEORIES.

Condensed from Mr. Siemens' paper before the British Association, the discussion, and the comments of the press.

Mr. Siemens set out with the statement that the present process of puddling was very defective, involving great loss of metal, waste of fuel, and of human labor, and an imperfect separation of the two hurtful ingredients, sulphur and phosphorus.

The molten pig iron in a puddling furnace is intimately mixed with the cinder formed in the furnace; the silicon is first separated from the iron; the carbon only leaves it during the later period of ebullition, and the sulphur and phosphorus separate last, while the metal is coming to nature. This much may be considered *proved* by analysis.

The old Theory of puddling adopted almost without investigation is plausible enough at first sight, and is thus stated: The pig iron when melted in the air furnace, being brought in contact with the air in its entire mass by mechanical stirring, undergoes an oxidizing process analogous to that which takes place in the Bessemer converter, the oxygen of the *air* taking away the silicon, carbon, and other impurities one after the other in proper succession. The iron ore used for felting (American, "fixing") combines with the silica formed by the oxidation of the silicon in the pig iron, and forms the puddling furnace cinder, which is charged moreover with different combinations of the phosphorus and sulphur originally contained in the pig iron.

Mr. Siemens' theory is that the pig iron, when molten in the puddling furnace and kept in contact with the fettling (which latter may be considered to consist of nothing but iron and oxygen) requires no oxygen from the air for being converted into wrought-iron. All that is required for its decarburization and desilicatization is an intimate contact of all the particles of iron with the liquid cinder formed from the fettling at a high temperature. The oxide of iron will then be decomposed by the silicon and by the carbon existing in the pig iron, and a large proportion of iron will in this manner be reduced from the ore.

Mr. Siemens goes a step further, and proves by the evidences of all the phenomena connected with the puddling process in an ordinary furnace, that even in presence of an oxidizing flame, the oxygen for decarburization is taken principally from the ore, and not from the atmosphere of the furnace.

Mr. Siemens' chemical reasoning is as follows: *Silicon.*—In forming (by the rabble) an intimate mechanical mixture between the fluid cast metal and the cinder, the silicon in the iron is brought into intimate contact with metallic oxide; being found afterwards in the form of silicic acid (combined with oxide of iron), it follows that it must have reduced its equivalent of iron from the cinder to the metallic state.

Carbon.—The disappearance of the carbon is accompanied by violent ebullition, and the appearance of carbonic oxide. The appearance of the process proves that the combination of the carbon and oxygen does not take place on the surface, but throughout the body of the iron. Mr. Siemens has also observed that no oxidation of fluid cast-steel melted on the open flame bed of a furnace, takes place as long as it contains a particle of carbon. Hence he concludes (by rather a long jump, we think) that the *oxidizing action* of the flame in a puddling furnace commences only after the malleable iron is formed, and hence the oxygen of the *atmosphere* of the furnace did not remove the carbon and silicon.

As to loss in the process, Mr. Siemens gives a calculation, the result of which is that assuming the pig to contain 3 per cent. of carbon and 3 per cent. of silicon, 10.5 per cent. of metallic iron should be added to the bath from removing the carbon, and 8.4 per cent. from removing the silicon, = 12.9 per cent. or 474 pounds of wrought-iron from a charge of 420 pounds of pig, whereas the actual yield is 370 pounds or 12 per cent. loss. He makes another calculation to show that 74 pounds of cinder are necessary to produce this 54 pounds of reduced iron, and says that this amount of cinder is considerably exceeded in practice. He quotes Dr. Percy as to the removal of phosphorus and sulphur (which are insufficient to affect the foregoing *quantitative* results, however they may affect *quality*) viz., that the crystals of metallic iron as they form throughout the boiling mass, exclude foreign substances just as water does in freezing—salt water forming ice that yields sweet water upon remelting.

Objections to the Theory.—As to the removal of carbon, by the cinder alone, rather than by the aid of the oxidizing flame, Mr. Siemens only presents a theory; if he has facts, he has unfortunately neglected to mention them; he does not say whether he used an oxidizing or a neutral flame in his practice. It is universally admitted that during the earlier period of the process, the presence of free oxygen is an advantage; it stimulates and facilitates the process, and entails no danger of oxidizing or burning the iron itself. The excellent results of the Richardson process of puddling—the tubular rabble to supply air, certainly show a decided action resulting from the *atmosphere* of the furnace.

As to the theory of removing silicon without the aid of an oxidizing flame, it is objected (in "Engineering") as follows:

The analyses of a puddling furnace charge in its various stages of progress show that the silicium is removed at the earliest stage, and that it disappears slowly and gradually during the process of melting and stirring, and before the commencement of the "boil." At that period the fettling is not *melted*, nor can it melt until it is converted into a silicate by the combination of the oxide of iron with the silica formed from the silicium in the bath. Silicium can take oxygen even from a neutral flame by decomposing the carbonic acid of the flame, but we have no evidence of its capability of reducing oxide of iron when in contact with it at a high temperature. On the contrary, it is known that a bath of pig iron when kept in contact at a high temperature with a slag of silicates, will reduce silicium from that slag at the expense of the carbon contained in the liquid pig iron. This property, too, is the cause of the difficulty which exists in the puddling process, and also in the Bessemer process to remove all silicon from the pig iron when the latter contains a very high percentage of that substance.

In reply to this Mr. Siemens states ("Engineering," October 2) the results of experiments showing that no silicon is taken up by the fluid cast metal in contact with silica or silicates. He charged 10 cwt. of Acadian pig metal and 1 cwt. broken glass upon the bed of a regenerative gas furnace (usually employed for melting steel upon the open hearth). The bed of this furnace was formed of pure silicious sand. The iron contained silicon 1.5 per cent., carbon 4 per cent. Analyses were made at the end of each hour, the silicon gradually decreasing. The reduction of the silicon might be accounted for by the presence of minute quantities of oxides of iron produced in melting the pig metal, which oxides were now increased by the addition of hematite ore in small doses. At the end of the fifth hour the samples taken from the fluid bath assumed a decidedly mild temper; when the addition of ore was stopped, and exactly 6 hours after being charged, the metal was tapped and run into ingots; it now contained silicon .046 per cent., carbon .25 per cent. Thus both the silicon and carbon had been almost entirely removed from the pig metal by mere contact with metallic oxide under a protecting glass covering. The quantity of red ore added to the bath amounted to 2 cwt., and the weight of metal tapped to 10 cwt. 5 pounds, being slightly in excess of the weight of pig metal charged.

We consider it probable that the advantage of Mr. Siemens' practice over the old practice is that it is performed in his gas furnaces in which the flame is absolutely under control, and that at the close of the process it can be made an absolutely neutral flame, instead of a partly or accidentally oxidizing flame to burn up the iron.

Mr. Siemens' new Practice is remarkable, however undeveloped or inadequately explained his theories may be.

During 18 months' working of a puddling furnace at the Bolton Steel and Iron Works, he has succeeded in making the yield of puddled iron in many cases fully equal to the weight of pig iron charged into the furnace. With regard to the economy of material, experience had proved that an ordinary furnace receiving charges of 484 pounds, yielding an average of 426 pounds, represents a loss of 12 per cent.; whereas his furnace received charges averaging 428 pounds, and yielded 413 pounds, representing a loss of 3.5 per cent. It was important to observe, moreover, that his furnace turned out 18 heats in 3 shifts, in 24 hours, instead of only 12 heats in 24 hours, which was the limit of production in the ordinary furnace. The quality of the iron produced from his furnace was also decidedly superior to that from the ordinary furnace. Beyond these considerations the consumption of fuel was also greatly in favor of his furnace, estimated at 25 per cent.

The consumption of the fettling was greater in the gas furnaces, and the superior yield was naturally attributed by forge managers to that cause. But the subsequent introduction of water bridges reduced the amount of fettling to an ordinary proportion, and experiments then proved that the use of his furnace gave an average yield of fully 12 per cent. above the ordinary furnace, while the iron was of better quality.

The Siemens' Furnace consists of a puddling chamber of very nearly the ordinary form, which, however, is heated by means of a regenerative gas furnace, the principle of which is well established. The advantages of this furnace for puddling are, that the heat can be raised to an almost unlimited degree; that the flame can be made at will oxidizing, neutral, or reducing, without interfering with the temperature; that in-draughts of air and cutting flames are avoided, and that the gas fuel is free from pyrites and other impurities which are carried into the puddling chamber from an ordinary grate. In this respect the new furnace presents the same advantages as puddling with charcoal.

The Siemens' furnace enables us to perform the operation of puddling with the following advantages: We commence the charge with a hot clear flame, which is kept up until the charge is quite liquid and raised to a very high temperature; at that moment we shut off the supply of gas altogether, drawing into the furnace nothing but pure atmospheric air, intensely heated by its passage through the regenerators. This is an "oxidizing flame *par excellence*," and its action upon the bath, when assisted by stirring the liquid mass with the rabble, must be rapid and effective. The next change must be effected when the liquid mass begins to rise in the furnace. The gas inlet must then be opened to its full width, and a flame overcharged with gas must be maintained to the end of the operation.

Cost of Furnaces.—It was stated that a pair of Siemens' furnaces cost about £450, which was rather more than the cost of a pair of ordinary ones; but the gas furnaces would make one-third more iron, which was equivalent to one-third of the cost, and the saving in iron and coal would more than pay the expense of the furnace in one year.

FARMING MACHINERY.

The improvement of the portable steam engine, no less than of the locomotive steam engine, to meet the demands of agriculture, is one of the most important problems of the day. There are already in England stationary engines of 100 indicated horse power, employed to drag gangs of ploughs. The application of steam to the other operations of agriculture is almost equally important. "Engineering" says: When all the advantages of steam are fully understood by farmers we may expect to see it applied on thousands of farms where, thus far, it has never been seen. It will be employed to mix clay and sandy soils, assimilating the texture of hill top lands to that of those in the valleys. It will be employed to pump farm and other sewage to where it ought to be pumped for irrigation, for sheep washing, for stone breaking, and in many other ways. The worthy steam farmer will be a sort of factory owner and engineer-in-chief, and many of his men will be mechanics, engine drivers, and stokers. The great farms will be almost in a single field, levelled where possible almost like a drawing table. The steam farming (not barnyard) engine can equally draw a plough, a cultivator, a barrow, a seed drill, or a drain plough, and it is not clear why it should not also draw a reaping or mowing machine, provided it was made sufficiently wide to render the application of steam profitable.

There are no less than 300 steam ploughs and cultivating sets now used in England. "Engineering" estimates that they have broken up and pulverized from once to 6 or 8 times, at least half a million acres (possibly much more, for it is exceedingly difficult to form any accurate estimate), and that in a manner never before known since ploughs were invented. There are now ploughing engines capable of exerting 100 indicated horse power, and capable of putting a draught of 3 or 4 tons upon an implement at a rate varying between 3 and 4 miles an hour. With such power any depth can be reached, and as the disintegrating power is, by a well-established mechanical law, as the square of the velocity, the soil is broken with 4 times the mechanical effect at 4 miles an hour, as in the case of a horse-drawn plough at two miles.

The committees of the Royal Agricultural Society on steam cultivation, published in 1867, after examining some 200 steam-tilled farms, report that "A culture deeper than it is possible for horses to effect, works a highly beneficial change in the texture of the soil, imparts additional efficiency to drainage works, augments the value of the manure applied, brings into operation certain latent properties of the soil, which much increases its fertility; it also fits land, formerly unfit, for the growth of turnips, allows of their being fed off by sheep, the operations of the field are economized, and the growth of all crops is stimulated." At the time of their report steam tillage was considerably cheaper than horse tillage. Now, the steam ploughing engine, rope, and other tackle, and the attached implements, have been very much improved, and the comparison would be still more in favor of steam.

But the greatest gain is in the improved crops due to thorough tillage, and this may amount to an extra quarter of wheat per acre, an extra 3 or 4 tons of turnips, or something equivalent, and in this way the average crop may be increased possibly to the extent of £10,000,000. There are many recorded instances of steam-ploughed fields yielding 2 or more quarters of wheat per acre more than fields of the same character of soil alongside, but cultivated by horses.

Although there is probably no more efficient and economical power than steam for large operations, the substitution for "one horse" operations of some safer and more cheaply managed power than steam, as at present generated and used, should merit the serious consideration of the profession.

The "American Artisan" suggests also the following important problems for agricultural engineers: The development of *compound machines* for preparing, by different changes of parts, the food for animals, whether of grain or stalk or root; for disintegrating and preparing refuse mineral and vegetable substances for fertilizing purposes; for cleaning fields from stones; for the rapid and efficient construction of drains, and for many other purposes which would be developed in time, but can hardly be now foreseen.

THE EVIL OF HASTY WRITING.—The "Round Table" commences a timely article on this subject with the remark that American journalists write *too much*, and states that the leader writers for the "London Times" furnish but one to three articles per week. Such articles are well digested, and worth more than all the pages written "against time." If hasty journalism is a defect in polite and political literature, how much graver the defect in scientific literature. Technical articles, of all others, should be highly matured; when loose and hasty, and especially when spun out to fill so much space, they are too long to be read—practitioners cannot afford the time—and they are likely to be incomplete and inconclusive.

But, notwithstanding the vast increase of trashy writing, secular and scientific, there is a growing taste for higher literary excellence in the one department, and a growing and acknowledged want of more learning as well as a better style in the other. This taste and want exhibit themselves in the form of *pay*. The better class of readers are making it an object for the better class of writers to contribute to periodical literature.

THE ATLANTIC WORKS, East Boston, are building several iron steamers and their engines, and employ 350 hands.

RUBBER TYRES FOR HIGHWAY LOCOMOTIVES.

Compiled from Accounts in the London and Edinburgh Press.

Mr. R. W. Thomson's road steamer, recently tried about Edinburgh, has given a new start to highway steam locomotion. The improvement consists in the use of thick tyres of India rubber, which are said to make all roads good roads, and thus to overcome the grand obstacle to this otherwise most useful and economical means of transportation.

After trying a smaller locomotive with success, Mr. Thomson built one of 8 tons weight, having a vertical boiler, and standing on two geared driving and two steering wheels.

The driving tyres are made of bands of vulcanized India rubber 15 inches wide and 5 inches thick. This soft and elastic substance carries the great weight of the locomotive, without injury, over newly broken road-ballast, broken flints, and all kinds of sharp things, without even leaving a mark on the India rubber. It does not sink into the road in the least degree. It passed over the stones lying on the surface, and even over potatoes and carrots, purposely laid in its path, without crushing them. It resembles in some degree the feet of an elephant. As remarked by Professor Archer, in his paper before the British Association, both the camel and elephant have very large soft cushions in hard hoofs, and no other animals can stand so much walking over hard roads.

The power required to propel the locomotive is very much less than what would be required if the tyres were hard and rigid. They do not crush nor sink into the roadway. The machine, as it were, floats along on the India rubber, and all the power used in crushing and grinding the stones under rigid tyres is entirely saved. It might at first sight be supposed that it would take a great deal of power to propel a heavy carriage on soft tyres; but if the tyres are elastic as well as soft, the power used in compressing them in front of the wheel is nearly all given back as the elastic medium expands behind the wheel. In fact, the India rubber tyres require scarcely any more power to propel them over soft, bad roads, or over loose gravel roads, than on the best paved streets.

On a soft grass field, in which an ordinary steam carriage would have sunk, the rubber tyres were run without even leaving a track. On a field which had just been covered with loose earth to the depth of 1 or 2 feet, they ran straight across and back, without difficulty, and compressed the earth so little that a walking stick could easily be pushed down in the track of the wheels.

When riding on the road steamer the feeling is like what would be experienced in driving over a smooth grass lawn. There is absolutely no jarring. Thus the machinery is spared the severe trials arising from the blows and jolts to which it is subjected when mounted on common wheels.

There is, incredible as it may appear, no indication of wear on the India rubber tyres. The original surface which the rubber had when it left the manufactory is still visible.

The tractive powers of the machine have surpassed all expectation. It was constructed to drag an omnibus, weighing, with its load of say 30 passengers, about 4 tons, on a level road, but its capacity is so greatly in excess of this task, that no load placed behind it has fully tested its power. On a road so slippery from frost that horses had the greatest difficulty in keeping on their legs, no difficulty was found in going over the glazed surface by the India rubber wheels, with a load of 13 tons (a large boiler on a truck) on an incline of 1 in 12.

On one occasion, the locomotive drew a coal train, in all 90 feet long, consisting of 4 wagons, weighing, loaded, 32 tons, 8 miles, over grades of 1 in 16.

The steering of the locomotive while hauling the coal train in the crowded streets of Edinburgh, and around sharp corners, was very successful. The line of streets through which it passed are always the most crowded in the city, but at the time the train passed through these thoroughfares there happened to be an unusually great current of traffic passing in a contrary direction to where some games were going on, which gave rise to a great stream of omnibuses, cabs, and conveyances of every description, in addition to a great crowd of pedestrians. Notwithstanding all these obstacles, aggravated by the streets being at some points under repair and closed for one-half of their width, no difficulty was experienced in steering clear of every impediment.

The extremely curious way in which the whole 4 wagons follow, snake like, in the track of the road steamer was clearly seen in passing out of North Bridge into Leith street. First, the road steamer had to turn to the right, and before the last wagon was round the corner to the right, the road steamer had already turned sharp to the left to go into Leith street—thus the train actually assumed the form of the letter S, every wagon going over the same ground as the road steamer with the most perfect accuracy. The very steep and crooked descent of Leith street, which has a gradient of probably 1 in 12, was managed with perfect ease. The final manœuvre was turning with the whole train out of a street 30 feet wide, into a lane 25 feet wide, up a steep incline. It passed in at the first trial, leaving so much space to spare that it was found, on afterwards measuring the wheel tracks, a width of 14 feet would have sufficed, though the breadth of the wagons is 7 feet.

As to usefulness for Army purposes, the "Railway News" remarks that a few of these engines working up the Col de Balaclava might have saved many lives in the Crimean winter of 1854, and the increased weight of siege ordnance would now give to an engine of this sort an importance which it could not then have possessed.

BOILER EXPLOSIONS—THE PROJECTILE THEORY.—This theory, started by Zerah Colburn, and advocated by D. K. Clark and others, meets with confirmation occasionally, by circumstances which no other well-defined theory will explain. For instance, in the explosion of a boiler at Wustewaldersdorf bleachery in Germany, a detailed account of which is translated from the Journal of the Association of German Engineers, for the "Iron Age" of October 1, a manhole plate was blown off from the boiler by reason of defective bolts; a sudden liberation of a great volume of steam ensued, and an explosion followed, tearing the seams and the solid plate in various places.

The German writer (Mr. Heaffman) observes that explosions generally occur after the sudden liberation of steam, and adduces experiments with glass boilers, viz:—Opening the safety valve slowly, let off the pressure without disturbing the water; opening it suddenly caused such a rapid generation of steam bubbles as to place it in violent commotion; the pressure fell 3 pounds, and immediately began to rise, when the boiler exploded and was shattered to powder. Boiling water was pumped into another boiler, and then air forced in until the boiler burst at the much higher pressure of 15 atmospheres, but with less report, and no shattering.

Mr. Heaffman attributes boiler explosions to electricity. But the theory is not well defined; it is only a guess. The projectile theory, however wrong farther knowledge may prove it, is at least well defined, and in these and many explosions there are all the conditions required to produce it, viz.: 1st, the sudden relief of pressure; 2d, the flashing of much water into steam, because at a reduced pressure it cannot exist, hot as it is, as water; 3d, the violent escape of this steam *carrying water with it;* 4th, the instantaneous blows of innumerable projectiles, large and small, of inelastic water upon the plates, shattering them irrespective of weak places, like the effects of cannon shot.

OLD AND NEW OBJECTS OF INVENTION.—The inventions of the last hundred years sometimes appear more grand and far reaching than any now being developed or demanded. But it must be remembered that the old inventors had a clear field. Everything was demanded and nothing was done. The steam engine, the cotton gin, the telegraph, smelting with pit coal, the hot blast, the rifled cannon, and all the other great inventions which have changed the whole aspect of life, were then unknown, and even the most imperfect development of them was more striking and revolutionary than the later and really more valuable refinements of the same inventions. And it does not follow that less useful work is wanted or likely to be done now. On the contrary, the improvements in steam power, for instance, likely to be developed during the next hundred years, will have a greater money value than all that has preceded—perfect as the steam engine is to-day. The old inventors were called upon to discover and open the doors of Nature's storehouse; the later inventors are called upon to bring out and set in order her wonderful secrets.

THIRTY-FEET FAN—IMPROVED CONSTRUCTION.—The centrifugal ventilating fan of M. Guibal, a Belgian engineer, has given good results after a prolonged trial in the mines of the continent, and is now introduced in England. It had previously been thought advantageous to allow the air to escape from the vanes of an exhausting fan as freely as possible—hence the univeral system of discharging round the whole circumference. After much careful study M. Guibal found it better to enclose his exhausting ventilator in a casing, allowing the escape of air at one point only; and it was equally in accordance with mathematical principles that the adoption of this casing was followed by the use of the peculiar chimney and sliding shutter, which are important features in this system.

The objections generally brought against centrifugal ventilators were—1st, the high speed, and consequently heavy wear and tear and liability to breakages; 2d, the comparatively small depression obtained, and the loss of useful effect by re-entries of air—rendered greater as the depression increased; 3d, the low percentage of useful effect, which even with the best known system abroad did not exceed 25 per cent.

The first objection has been overcome by increasing the diameter of the ventilators, originally about 6 feet, and making 400 or 500 revolutions per minute, to 30 feet; and they are intended to be 40 feet diameter, making 60 to 80 revolutions per minute. The second objection has been met by enclosing the ventilator in a casing, the only inlet of air being from the mine into the centre opening, and by the chimney, which is specially constructed on the expanding principle, and utilizes a certain amount of the power which would otherwise be carried away by the air entering its base at the high velocity which it has on leaving the blades of the fan. The result of experiment proves that a depression greater than that due to the velocity of the tip of the blade is obtained from the Guibal ventilator; this is due to the joint action of the "Evasée" chimney. In other centrifugal ventilators the depression obtained has been less than that due to the velocity. The third objection no longer holds when such a result as 60 per cent. to 70 per cent. of the steam power applied is utilized.

A fan 30 feet diameter by 10 feet wide is driven by a direct acting single engine with cylinder 24 inches diameter and 24 inches stroke. Fans of these dimensions are now giving at 60 revolutions per minute, a volume of 100,000 cubic feet per minute, with a depression of 2.5 inches.—*The Engineer.*

TIN-LINED LEAD PIPES.—Messrs. Broadnax & Co., in New York, and M. Hamon, in France, are manufacturing tin-lined pipe in large quantities, and, whilst the inner surface insures a perfect freedom from all the deleterious consequences arising from the use of water brought into contact with lead, the increased strength obtained from the superior tenacity of the tin enables the section to be reduced and the pipes to be manufactured at the same prices as ordinary lead tubing.

The operation in the American process consists in casting a conical ingot of pure tin, which is then bored out to fit a mandril, the size of which corresponds with the diameter of the pipe to be produced. This ingot, after being turned down in a lathe, placed in a refrigerator, and reduced to a temperature of 12°, is set upon the mandril, which is fitted into the ram of an hydraulic press, and exactly in the centre of a circular mould, into which lead is poured from adjoining furnaces, placed on each side of the hydraulic press. The mould is placed within a casing kept heated to a temperature of 267°, to prevent the lead from chilling and parting from the mould. As the tin has been reduced to a temperature of 12° above zero, it resists the superior heat of the melted lead, and only begins to change form as the former is hardening. A perfect junction between the two metals is thus effected without so much fusion of the tin as would destroy the continuity of the lining when the pipe is drawn out. When the ingot is cold the descending ram forces it through a die, forming a continuous pipe, with a tin lining, the thickness of which depends upon the size of the central ingot.

The process of M. Hamon closely resembles the American one just described. In preparing his ingot, the inventor casts an annular block of lead, and placing within the central space a hollow mandril of a less diameter than that of the hole in the ingot, fills it with tin, which he runs in from the bottom of the ingot, through the hollow mandril. The compressing process is in all practical details identical in each case, the main difference consisting in the addition of an auxiliary hydraulic cylinder for raising the cast-iron block containing the matrix, through which the pipe is forced.—*Engineering.*

UTILIZATION OF SEWAGE.—One of the greatest sources of waste in all American and most foreign cities, is the throwing away of the valuable fertilizing elements in the sewage. In China, that semi-barbaric, but exceedingly wise old land, the inhabitants of cities are obliged by law and custom to return all fecal matter to the country, where it may be restored to the soil, from which it came in the shape of vegetable and animal food. But the fluid matter is not available for manurial use, and the solid matter is difficult of separation, except through the tedious process of evaporation. A compound (of animal charcoal, blood, clay, alum, and some other things) has recently been patented in England, by which the solid material may be instantly precipitated in a coalescent mass, which is easily and quickly dried for manure. Some enterprising "contractor" could make any number of fortunes by getting hold of such an effective process. The refructification of soils is getting to be an important question along the Atlantic States.—*N. Y. Times.*

Another process, patented by Mr. C. G. Lenk, of Dresden, is a peculiar preparation of alum. In a recent experiment at Tottenham (Eng.), 26,000 gallons of sewage were discharged into the tank, and into this were gradually poured about 60 gallons of "Lenk's Patent Essence." At first the smell was most offensive, and nearly intolerable, but as the chemical preparation mixed with the liquid the odor perceptibly decreased. After some time a remarkable change was visible in the contents of the tank. The solid substances were precipitated to the bottom, the water on the surface became gradually clear, and at the end of an hour it was found to be not only transparent, but almost clear, by contrast with its condition when discharged from the sewer.—*Artisan.*

IMPROVED METHOD OF TESTING LARGE PIPES.—An apparatus for testing pipes and open-ended castings has been designed and recently patented by Mr. Henry Cochrane, of Middlesborough-on-Tees. In testing pipes by water pressure, the usual practice has been to close the ends by caps or bonnets, and then to force in water until the pipe was completely filled; but in the case of pipes of large size this system is open to two objections, the first being that, as the end caps are subjected to an enormous pressure, they require very strong, and consequently expensive fastenings to hold them securely; and the second being that a waste both of time and of water is occasioned by its being necessary to fill the entire capacity of the pipe. Mr. Cochrane overcomes these objections by placing a core, slightly less in diameter than the bore, within the pipe, and then pumping the water into the small annular space between this core and the pipe itself. By this arrangement, not only is the quantity of water which it is necessary to force in very greatly reduced, but the end caps are also relieved to a corresponding extent of the pressure to which, under the ordinary system, they would be subjected.

This apparatus is illustrated in "Engineering," October 2, 1868. The pipe is run over the core on a carriage, and the joints are stopped at both ends by screwing a cap upon one end.

WORKING THE 12-TON GUN.—Let us now stand for a short time upon the Seawall Battery at Shoeburyness, and watch the Royal Artillery officer and his "detachment" of 13 men work the 12-ton 9-inch gun. The object they have in view is to fire as rapidly as possible, consistently with taking a steady aim, at a target of only 5 feet square, moving across the range at 1,000 yards distance. By this means it may be ascertained how often the gun can be discharged at a vessel which the gunners are able to keep under fire while she passes along a distance of 750 yards, at 1,000 yards distance. The gun is mounted upon a wrought-iron carriage with slides, the whole being traversed upon racers. In 1 minute and 17 seconds after the first round the gun is again loaded, laid, and discharged. The third round, at the same interval of time, strikes the target, which is then moving at the rate of $3\frac{1}{2}$ miles an hour. In 4 minutes 52 seconds 5 rounds have been fired. The speed of the target is now increased from 7 to 8 miles an hour, and in 3 minutes 22 seconds 5 more rounds are expended, the fourth shot hitting the target. The general result is that the gunners would have placed all their ten 250-pound shells in a small gunboat, or even in a man-of-war's launch, in 8 minutes and 14 seconds.—"*Our Heavy Guns*," *in Macmillan's Magazine.*

RESISTANCE OF SHIPS DUE TO THEIR DEPTH — INFORMATION WANTED.—In a paper before the Institute of Naval Architects, Professor Rankine stated that every ship is probably accompanied by waves whose natural speed depends on the vertical depth to which she disturbs the water; and that consequently where the speed of the ship exceeds that natural speed, there is probably an additional term of resistance depending on such excess. In a later paper before the British Association, he gives some observations that prove the existence of waves whose speed of advance depends on the depth to which the vessel disturbs the water. The relation between those waves and the resistance, remains a subject for future investigation; but to facilitate that investigation, he calls for farther observations, such as the measurement of the angles of divergence of the wave ridges raised by various vessels at different speeds, and the determination of the figures of those ridges—also the mean depth of immersion as found by dividing the volume of displacement by the area of the plane of flotation, and that not only for the whole ship, but for her fore and after bodies separately.

FIRE PROTECTION AND WATER SUPPLY.—The system of Mr. B. Holly, of Lockport, in use in Auburn and other cities, consists in *forcing* water through the pipes of a city by powerful pumps, instead of drawing it from reservoirs, and also in the use of a "water telegraph" to indicate where and when the supply is wanted. The system is very fully discussed in the "Iron Age" of October 15.

THE ELECTRIC LIGHT—Berlioz electric light, used (and exhibited in New York) on the steamers of the General Transatlantic Company, is said to penetrate the densest fog and darkness, and to be of great value not only on deck, but in the streets of cities. This light is produced by the burning of carbon pencils in currents of electricity. The latter are furnished without the use of batteries by an apparatus consisting of 40 series of horse-shoe magnets set in a circular frame, within which is an axis bearing 64 reels of copper wire, and revolving before the magnets at the rate of 300 turns a minute. A double current of electricity is thus induced in the copper wires, the one direct as they approach the poles, the other reversed after they have passed them. No device for breaking the current is used, as it is found that, though the current is interrupted at each reversion, the light is not perceptibly affected unless the interruption exceeds one-twentieth of a second.

The magnetic apparatus is about 4 feet 6 inches square; it stands in the engine room of the *St. Laurent,* and is driven by a donkey engine of 1 or 2 horse-power. The electricity is conveyed to the lantern by wires. The cost of the light is about 12 cents an hour; the same amount of light by gas would cost 2 dollars. The light is displayed through a Foucault lens, which can be turned by hand in any direction, placed on the bridge above the deck.

Some interesting experiments have lately taken place in France on board the armor-clad ship "Heroine," and also on board the yacht "Prince Jerome," upon the use of the electric light for signalling purposes. The power of the light obtained was equal to 200 Carcel burners—the Carcel being equal to 8 candles; it therefore follows that the electric light possessed a brilliancy equal to 1,600 candles! In the direct line of the light it was stated as possible to read at the distance of 1,400 metres (1,531 yards) an ordinary newspaper. It was found that signalling by means of short and long flashes was the most easily to be carried out. The commissioners on the subject report, "The apparatus experimented upon shows a very powerful focus of light, perfectly suited to night signalling, or for throwing a light over a coast or a ship. It can be considered as a veritable floating light, and would then be most useful on board the flagship of a commander-in-chief." Of the peculiar value of this light and its intense illuminating power, it is stated that the yacht "Prince Jerome," fitted with it, was enabled to steam by night through the intricate navigation of the Bosphorus, when the yacht belonging to the Viceroy of Egypt was obliged to wait until daylight.

THE ST. LOUIS BRIDGE.

The arches of the bridge commenced by Captain Eads over the Mississippi at St. Louis, are thus commented upon in "Engineering."

In one respect the Mississippi bridge differs essentially from the ordinary run of arched bridges. Usually the spandril filling, even if arranged vertically only, possesses sufficient inherent stiffness, by virtue of the rigidity of its connections with the arched rib and horizontal girder, to assist materially in preventing any distortion of that member when under strain.

In the instance of the Mississippi bridge the spandril verticals are positively hinged, so that not the slightest incidental support is afforded by them to the arched rib, the stability of which is, consequently, since there is no horizontal girder, governed entirely by the self-contained diagonal bracing.

In fact, the essential part of the bridge is a curved rectangular beam, 8 feet by 44 feet, the former dimension being the vertical depth of the bracing, and the other one the distance apart of the face ribs, which are firmly tied together by horizontal bracing. There can be no question as to the lateral stability of the structure, but the depth of vertical bracing is so small in comparison to the span—8 feet to 515 feet—that it is absolutely necessary to consider the question of stability in that direction. Now, there must obviously be some limit below which the depth of the arched rib could not be reduced, even if the load were always uniformly distributed, and the mathematical position of the centre of pressure corresponded with the centre line of the rib. Thus, if the rib were but 6 inches deep, it could no more maintain its form, for an instant, than it would if built of ropes. Why a depth of 8 feet should be assumed, as it is in the calculations, to afford perfect immunity from all disturbing forces, we are at a loss to guess.

It appears to us that an arched rib, *per se*, is neither more nor less than a long column, and that it should, consequently, be treated as such. In a long column of uniform cross section, subject to two equal and opposite end forces acting at the centre of gravity of the cross section, the unit strain would, mathematically, be uniform throughout the entire column. Experiment proves, however, that in consequence of variations in the elasticity of the material the strain is in reality very unequally distributed over the cross sections; so much so, that in columns of certain length positive tension is induced by a compressive force. Now, how it is that in calculations concerning arched ribs, or, in other words, curved columns, the unit strain should be assumed uniform if the mathematical position of the centre of pressure at any point corresponds with that of the centre of gravity of the cross section at the same point, whilst in a straight column, under similar conditions, it is shown by experiment to differ so widely from it, is not to us apparent.

In the Mississippi bridge, the least dimension of the column is about $\frac{1}{64}$th of the length; but on account of the curvature of that member, it is in effect, to a certain extent, supported at the centre of its length; hence the equivalent ratio will be greater than the preceding fraction. We have not investigated the question minutely, but theory appears to indicate that the equivalent ratio would be $\frac{1}{64} \times \sqrt{2} = \frac{1}{45}$th of the length. If this be so, the elastic resistance of the steel to be employed in the bridge should have been deduced from that of a bar 45 inches long by 1 inch diameter, instead of from that of a bar 12 inches long only, as appears to have been done. In no instance do we remember the breaking strain of either a solid or hollow column being greater than $12\frac{1}{2}$ tons per square inch, or about one-half only the resistance a short column of the same material would offer. In a steel column the loss of resistance would probably be smaller in proportion, but it would unquestionably be far too serious in amount to be neglected in the computations of the strength of Mississippi bridge. We do not mean to assert that, even if the maximum strain were 25 per cent. greater than stated in the report, the bridge would not still be perfectly safe and serviceable; but, at the same time, we cannot account for the omission of this important element in calculations so refined as those instituted for the determination of the strains on that structure.

We cannot endorse all the statements advanced in the report as to the superior economy of employing iron or steel in compression. In fact, if the reasoning were sound, it would follow that the resistance of a cylindrical boiler flue to collapse would be greater than its resistance to a bursting pressure. It is well known, however, that even an approximation to this condition would, in practice, be attended with fatal results. The radius of the arched rib of the bridge we are considering is about 84 times its depth, so, within certain limits, it may be considered as placed under similar conditions to a cylindrical flue 7 feet diameter, constructed of $\frac{1}{2}$ inch steel plates, and subject to external pressure. The increased resistance which such a tube would offer, if properly stiffened by diaphragms, is well known to practical men, and precisely analogous support would be afforded to the arched rib if the spandrils were properly braced. Neglecting the element of the long column, the present arrangements would probably be the most economical; but if we include that in the consideration, it will be found that the increased strains from expansion, contraction, and deflection, due to the bracing of the sandrils, will be more than counterbalanced by the increased resistance the arched rib could offer to compressive strains, whilst, at the same time, the structure would be far less liable to vibration.

In illustrating the bridge, "Engineering" adds the following comments: We think a glance at the engravings will convince most English engineers that the question raised by us, as to the vertical *stiffness* of the bridge, was not without good reason. The mass of horizontal bracing is so considerable in comparison with that available for the prevention of distortion of the arched rib in a vertical plane, that at first sight it might be fairly concluded the greatest disturbing force was to act in a horizontal plane, whereas, as a matter of fact, we well know the force operating in that direction could never amount to a tithe of the vertical disturbing force induced by the passage of a heavy rolling load over the bridge. In fact, as designed, we think the St. Louis Bridge would hardly prove less lively than several existing suspension bridges.

CHEMICAL PREPARATION OF PAINT.

Building News.

It has been proved that the different paints employed in the decoration and preservation of timber, iron, and other constructive materials, are not simple mechanical mixtures of oil and mineral substances but true chemical compounds, and endowed with that closeness and intimacy of union that invariably attends similar combinations.

Recently, the French navy has ordered a new process of preparing paints, to be examined and reported upon by a special commission. By proceeding upon a chemical rather than a mechanical principle, it is stated that paints may be manufactured in any quantities in a very short space of time, and in a simple and economical manner, which would dispense with the greater portion of the heavy and expensive machinery at present required. Any one may satisfy himself of the fundamental principle upon which this new process is based. Make a small cake, of a very fluid constituency, with some water and a certain proportion of any of the following ingredients:—White zinc, minium, or lamp black. Add to this cake a quantity of linseed oil; if zinc be used the proportion of oil will be 32 parts to 100, if minium only $5\frac{1}{2}$, and for lampblack 110 parts will be required to 100 of that substance. The mixture should be well stirred, and after a few minutes the oil will be found to be chemically united with the mineral substance, and the water to have separated and floating upon the surface. This circumstance is manifestly due to the principle of "elective affinity," by virtue of which the mineral substance leaves the water and unites itself to the oil. The water having been drawn off, the cake is then consolidated and pressed something after the manner in which butter is made. The process can only be applied to certain mineral substances, among which are those principally used in the manufacture of oil paints.

The following is an outline of the proposed manufacture: The color or mineral substance after being finely powdered, is mixed with a large quantity of water, and then passed through a fine sieve or strainer of silk. The small residue can be repulverized in a mortar and ultimately utilized. The chief advantage claimed for the sieve is that it arrests many foreign substances. This is not completely accomplished by the cylinders used in the ordinary manufacture of paints. The foreign particles are cut up very small, but they are not crushed; after a short time blisters rise to the surface, occasioning much damage to the appearance of the work. The mixture, after passing through the strainer, is deposited in a tank, where it may remain, if desirable, for some months. After drawing-off the greater part of the water, the proper proportion of oil is added, and the mixture thoroughly agitated. The result is that the cake commences to form, and is precipitated to the bottom of the receptacle. It is then pressed to drive out the remainder of the water, and although a very little may permanently remain, yet it will not affect the value of the paint or injure its application.

The successive steps may be summed up as follows:—The action of the water facilitates the minute division of the mineral substance or coloring matter; that of the strainer arrests all impurities, while the extreme degree of division to which the mineral has been brought favors its ultimate combination and chemical union with the oil. By virtue of its specific gravity the newly formed pigment, insoluble in water, separates spontaneously.

THE PRODUCTION OF COTTON SEED OIL. The cotton seed in its ordinary condition weighs about 33 pounds per bushel, of which about one-half is oil-yielding kernel, and the rest husk or hull, the latter being covered with a short woolly coat of fibres or filaments. In the usual method of extracting the oil this hull is removed by machinery, and the oil is expressed from the kernels by subjecting the same to great pressure after being ground, about 60 gallons of oil being obtained from a ton of the hulled seed. The oil weighs about 8 pounds to the gallon, and may be used not only in the manufacture of soap, but for grinding paints, and, when of first quality and properly refined, as a table oil in the place of that obtained from olives. One reason why this branch of production has not thriven better may, perhaps, be found in the employment of costly machinery, which not only involves a large original outlay of capital, but necessitates the consumption of all the seed of a large neighborhood in order to keep the apparatus constantly, and thus profitably employed, while the most available method would appear to involve the use of cheap and easily-operated machinery. This would enable each proprietor to extract the oil from the seed at such times and under such circumstances as might be the most convenient, and to employ the cotton seed as manure to nearly the same extent as if the crude seed were buried in the earth, inasmuch as the oil is simply a hydro-carbon, worth comparatively little as a fertilizer, while the pomace or oil-cake, containing the mineral matter and substances capable of generating ammonia, could be used for manurial purposes.

The "American Artisan" calls the attention of inventors to this subject, and indicates the direction of improvement.

THE HYDRAULIC RAM.

Condensed from the American Artisan.

This machine, a well-known invention of Montgolfier, is used where a considerable flow of water with a moderate fall is available to raise a small portion of that flow to a height exceeding that of the fall.

A dam is erected across a stream so as to form a pond. From the lower part of the pond runs the supply-pipe, *near* the end of which is a waste-valve chamber, in the top of which is a conical waste valve which opens downwards, and which is large enough to pass the flow of the supply-pipe. At the end of the supply-pipe there is a conical valve opening upwards into an air-chamber, from the bottom of which the discharge-pipe rises. There is a valve on the top of this chamber which opens inwards, and admits a small quantity of air, to supply any loss caused by its diffusion in the water.

The following is the operation:—Suppose the waste valve to have been shut by pressure from within the supply-pipe, and to fall suddenly open, owing to the diminution of that pressure. The water then begins to flow from the reservoir through the supply-pipe and out at the waste valve, with a gradually increasing velocity. The weight and the load of the waste valve are so adjusted that the impulse of the current in the supply-pipe upon it with the maximum velocity, causes it suddenly to shut. Thus the flow of water through the supply-pipe would be instantly checked, if it were not for the instant opening of the valve at the *end* of the supply-pipe into the air-chamber, caused by the momentum of the water. When the pressure in the air-chamber is equal to the pressure in the supply-pipe, the valve between the two vessels is closed by gravity. During the flow of water into the air-chamber, and for a short time after the closing of the valve, the water is forced up the discharge-pipe by its momentum and by the pressure of air in the air-chamber. As soon as the pressure within the supply-pipe is reduced by the stoppage of its flow into the air-chamber, the waste valve opens and permits the escape of some of the water in the supply-pipe, and remains so until the current is again strong enough in the supply-pipe to close the waste valve and cause the water to force itself again into the air-chamber and through the discharge-pipe to the desired elevation.

The following proportions for hydraulic rams have been found to answer in practice:—Let h be the height above the pond to which a portion of the water is to be raised; H, the height of water in the pond above the outlet of the waste valve; L, the length of the supply-pipe, from the pond to the waste valve; D, its diameter; then $H=h\div 20$; $L=2.8\,H=0.14h$; $D=H\div 10=h\div 200$.

If Q be the whole supply of water in cubic feet per second, of which q is lifted to the height, h, above the pond, and $Q-q$ runs to waste at the depth, H, below the pond; then the efficiency of the ram has been found by experience to have the following average value:—$q\times h\div Q\times H=$ two-thirds nearly.

THE COMSTOCK lode in Nevada, valued now at $30,000,000, was sold by the discoverer for a horse.

ECONOMY OF CLOTHING BOILERS.

The following are the results of some experiments recently conducted at the Newport Ironworks, Middlesborough-on-Tees, to test the value of a good lagging—Jones's non-conducting cement. The boiler (vertical) was connected with a puddling furnace, and was not protected by a roof. It was worked at 50 pounds per square inch, and in the second experiment the whole of the shell, an area of about 280 square feet, was coated with the composition. During the experiments the weather was fine and warm, and the coal used, the iron produced, the time of the experiments, and all the other circumstances, were exactly similar in the two cases. A water meter was attached to the feed-pipe, and this showed the exact amount of water evaporated with and without the covering. The results were as follows:

Boiler not Covered.

Total water vaporized per meter, Monday to Saturday, 11,690 gallons.

Total time, 126 hours$=92\frac{3}{4}$ gallons$=$14.8 cubic feet per hour.

Boiler Covered.

Total water vaporized Monday to Saturday, 16,060 gallons.

Total time, 126 hours$=$127.5 gallons$=$20.4 cubic feet per hour$=$5.6 cubic feet per hour more than when the boiler was uncovered, a difference which plainly shows the immense loss of heat under the latter circumstances.

Experiments by Jacob Perkins long ago proved that in case of pipes filled with steam at 100 pound per square inch, 100 feet of surface exposed to the atmosphere are, under ordinary circumstances, sufficient to condense per hour the steam produced by the vaporization of a cubic foot of water.

Regarding this experiment "Engineering" says: "It will be seen that a square foot of ordinary heating surface has about one-fifth the heat-transmitting power of a square foot of freely exposed cooling surface; or supposing that in any given boiler the areas of heating and cooling surface are equal, the effect of the latter, if freely exposed, would be to reduce the evaporative efficiency of the boiler twenty per cent.

The exposed surface of a boiler, or its cooling surface, in no way differs from its heating surface; it is subject to the same laws, and, under similar circumstances, would produce similar effects. That a square foot of cooling surface withdraws from the contents of the boiler a less amount of heat than is imparted to them by an equal area of heating surface, is merely due to there being a less difference between the temperature of the atmosphere and that of the contents of the boiler, than there is between the latter and temperature of the gases in the flues. Other circumstances being equal, the transmitting power of any given area of boiler surface varies directly as the difference in the temperature on the two sides of it, any increase in this difference enabling the surface to transmit a proportionately increased amount of heat in a given time.

AN ACADEMY OF USEFUL SCIENCE.

In these days of national institutes and guilds of letters, it is a little singular that the practical sciences to which this age, and this country especially, owe their progress, should not be promoted and conserved by a national institution, not only respectable in names and talent, but powerful in wealth and numbers.

It should seem that we do not know the foundations of our physical progress. Were a philosopher of a previous century to revisit the modernized earth, to observe the revolution in every mode and attribute of life—the dissolving and recomposing of materials, the utilization of natural forces, the wonders of chemistry, the feats of engineering, the triumphs of machinery, the omnipresence of iron—were he to witness the grander features of modern science, the splendid works and enginery of transportation, transformation, and construction—the steamship, the locomotive, the telegraph, the iron bridge, the Bessemer process, the machinery of agriculture, of water supply, of illumination, of weaving, of printing, of compounding, eliminating, and shaping materials for infinite uses, of turning power into infinite channels, and the machinery that makes machinery—were he then to study the minuter and every-day relations of modern science to life, to rest and motion, to pleasure and work, to living and dying, to the exercise of every sense and the utilization of every perception, till the surging masses around him should seem so many modern Centaurs—half man, half engine—were he then to contemplate the vast and complex organization of this modern life, its political and social bearings, and the amelioration of human fibre and force by inanimate substance and power—were this ancient philosopher to witness these marvellous things, his first thought would be of the great conservatory of their laws and literature—the modern Athenæum in which they are developed and organized, and he would turn to look upon the crowning wonder of them all.

But he would look in vain. The greater wonder is that modern engineering, by which we mean, comprehensively, the science that utilizes the forces and materials of nature, has so far advanced without organized association of ideas. Each individual or school has to a great extent begun at the bottom of the ladder. The hard-earned knowledge of one has been of limited benefit to the others. One is groping to-day for what has been the settled practice of another for years. How much labor and money have been misapplied to the rediscovery of what was known, and only needed dissemination to have turned all this labor and money to a vaster unfolding of the unknown. How many seeds of splendid growth have brought forth common fruit because planted in uncultivated ground. How many mighty intellects and industries that could have reared the monuments of engineering to the skies, have passed away, leaving nothing but duplicates of their foundations.

But, upon closer inquiry, we find that the present progress has been chiefly the development of what previous schools had left unfinished, and that professional literature, institutions of learning, commissions, conservatories and museums, limited, local, and inadequate as they have been, were the real organism of progress. To supply in some degree the knowledge of current facts and practice, each enterprising individual and community of workers in engineering is sending its agents and commissions all over the world to find out the same thing, when the machinery of a common institution of engineering would send more and better knowledge not only to every scientist, but to every artisan. How vastly the safety and economy of railway transportation, for instance, would be enhanced by the dissemination of facts. Each one of the ten thousand engineers engaged in its construction, maintenance, and improvement, is toiling after what some hundreds of them know. And no hundred private authors, investigators, and experimenters, can meet the demand for this knowledge. They all tread over the same ground—the sum of their results is overwhelmed in the volume of their concurrent testimony, and no individual practitioner has time to digest and utilize it. If thorough, it is limited; if comprehensive, it is incomplete. Individual powers and fortunes are inadequate. Such investigations do not keep pace with improvement. The good practice of this year may be bad practice next year. The influence of knowledge thus acquired is local and limited. For these and other reasons it is not only a minimum result at a maximum labor and cost, but it is not faithfully and literally pursued nor intelligently followed.

A great central guild of engineering would, at the cost of the present independent investigations, present to the world the latest facts briefly, completely, and authoritatively. *Organized* research would not go round in a circle. Each of its Commissioners and Boards would have its right line of investigation, its compilers would separate the wheat from the chaff, and its publications would be the text-books of the profession. Then would the thinkers and workers in the great arts of engineering widen the range, elevate the character, and magnify the usefulness of its results, and not merely multiply the proofs that these heights are attainable. —*New York Times.*

MACHINE-MADE WATCHES.—The American Watch Company employs over 600 operatives, and has made nearly half a million watches. The success and economy of the manufacture lies in the fact that everything is done, as far as possible, by machinery.

WOOLLEN MANUFACTURE IN THE WEST. There are at the present more than 550 woollen mills in seven of the Western States, having altogether a capital of about $5,500,000. Western wool is beginning to be consumed at home.

MARINE BOILERS.

As compared with ordinary land boilers, the modern marine boiler is a light and compact, if not remarkably strong structure. But if we compare it with the locomotive boiler, it at once becomes a hulking, clumsy contrivance, to say the very best for it. Its weight, together with the water contained in it, will not fall much short of 5 cwt. for every cubic foot of water evaporated per hour, whereas one-third this weight answers in the locomotive.

When we consider how badly a thin and nearly square box—and the shells of nearly all marine boilers are little more than square boxes—is calculated to withstand internal pressure, we perceive the first element of weakness and consequent weight.

When, again, we perceive what a small proportion of tubular surface is presented in comparison with the extensive but indifferently effective vertical surfaces of half inch plates, and besides these the considerable surfaces under the ash-pit—generating little or no steam—there is nothing to wonder at as to weight. Water bottoms were absolutely necessary in wooden ships. Are they necessary or even desirable in iron ships? Locomotive boilers give a good rate of evaporation without them. Indeed, they have been tried on locomotives without the least advantage. And as for dividing the length of a boiler by means of 5, 6, or 7 water legs, into 4, 5, or 6 separate and distinct furnaces, what is the good of it? Look at the weight of plates, the stay bolts, the angle iron or flanging, the hand holes and the cleaning—and all for what? No doubt the "legs" unite the furnace crowns with the water bottom, and if not so secured the latter would endeavor, and no doubt successfully, to straighten itself out, like the hollow spring of a Bourdon gauge, into a vertical line with the back of the boiler. But if there was no water bottom there would be no straightening tendency of the kind; and even with a water bottom a water front, as in a locomotive firebox, would most effectually tie it to the crown plate, and, still more, very sensibly diminish the heat in the boiler room. As to a great flat crown plate 15 feet by 7 feet, more or less, it would be no more difficult to stay than the crown plates

5 feet by $4\frac{1}{2}$ feet of broad gauge locomotive fireboxes worked to 4 times the pressure per square inch. Nor would there be any difficulty in keeping the crown plate clean. The room now taken up by the "legs," 6 inches or more each, would be occupied by 2 additional vertical rows of tubes of hardly one-fourth the thickness, yet presenting much more effective surface. But if the furnaces must be separated like pigeon holes, or little chaples of ease, make the legs a foot through and perforate them with 4-inch tubes. These would give much additional surface of the most valuable kind, and they need not interfere with proper cleaning.

Marine boilers made with cast-iron ash-plates instead of water bottoms, and having no divisions between the furnaces, would weigh much less than at present, be much cheaper in first cost, and would present far more of the most effective heating surface, viz., of horizontal plate with the fire beneath it. The grate area would be enlarged, narrower air spaces would suffice, the draught would be better equalized, thinner fires maintained, and the "combustion chambers," or space for the mixture of the gases with air, would be very much increased.

All marine boiler tubes ought to taper, being smallest at the front or smoke-box door; but, unfortunately, if so made, they could not be set in the boiler, as there would be no room to enter them at or withdraw them from the rear end.

It would be worth while to consider also whether some form of furnace like the Wilson furnace could not be adopted in connection with marine boilers. In this case, with boilers fired athwart ship, they could be brought very much closer together, and the boilers on both sides fed simultaneously from a raised stage, on which the men could stand with comfort. If such a furnace were found to answer it would require feeding only through a hopper, and no slicing of the fire, or dragging the grate bars from beneath, inasmuch as there are no bars, and none but absolutely incombustible refuse.

The foregoing is from "Engineering." "The Engineer" objects to the locomotive boiler as difficult to place and work in a ship, and inconvenient to repair. It says: The more widely a boiler departs from the well-known return fire-tube or flue types, the more unsuitable has it proved itself for sea-going purposes, and therefore only return-tube and flue boilers are now used in the best practice. Nor is it difficult to determine why such is the case. Good tubular marine boilers evaporate as much water per pound of coal burned as any other boiler of similar dimensions that can be placed on board ship, while they last much longer and do their duty during their lifetime with more certainty than more complex arrangements. This may be all wrong in theory, but it *is* practice. The fact has been proved by over 20 years of experience. It is quite true that the marine boiler is not well calculated to carry high-pressure steam, but it is also true that boilers specially intended to carry high steam are unsuitable for use on board ship; nor has it been proved that peculiar advantages are to be derived from the use of very high pressures at sea.

"The Engineer" objects to large crown sheets as difficult to stay, unprecedented, and difficult to keep covered with water. To which "Engineering" responds: The celebrated American river steamer New World had 2 boilers and only 4 furnaces. With a working pressure of 45 pounds per square inch, their nearly flat crown plates were each 10 feet 6 inches long, thus presenting a nearly flat surface of $65\frac{5}{8}$ square feet, upon which the total steam pressure was nearly 200 tons, or 800 tons for the 4 furnaces. The evaporation, as given in Mr. Bartol's admirable work on marine boilers, was 7 pounds of water per pound of coal. The Isaac Newton had 2 boilers worked to 35 pounds pressure, the 4 furnace crowns being each 5 feet 9 inches wide and 9 feet 6 inches long, the length of grate being 7 feet. This vessel, with fan blast under the grate, burnt 50 pounds of anthracite per square foot per hour, with an evaporation of 6.2 pounds water to the pound of coal. The America, a steamer on the Delaware, has a single boiler with but 2 furnaces, each fired through 2 doors, and each crown plate of the enormous width of 7 feet 6 inches, and of the length (for a 7 feet grate bar) of 28 *feet*, and the rate of evaporation at 25 pounds pressure, is given by Mr. Bartol as 7.82 pounds water to the pound of coal, $29\frac{1}{2}$ pounds of coal being burnt per square foot of grate per hour. The 2 boilers of the Bay State, giving off steam of 25 pounds from sea water, and running daily for a considerable distance on the open Atlantic, have 4 furnaces with flat crowns 5 feet 6 inches wide, and 10 feet 4 inches long, the rate of evaporation being 5.82 pounds water to the pound of anthracite, and the combustion of the latter 38 pounds per square foot of grate per hour. Furnace crowns from 4 feet to 5 feet wide, and worked under pressures of from 15 pounds to 35 pounds, and under very rapid rates of combustion, are exceedingly common in American practice. In Weale's "Engineers' Pocket Book" for 1847–48 is a drawing of a very successful boiler, in which the crown plate of the furnace, nearly flat, is 11 feet 6 inches wide and 9 feet 6 inches long.

If we go from furnace crowns to grate areas we find, on looking at the boats of the western rivers of America, having their 6, 7, or 8 cylindrical boilers, externally fired, and loaded from 90 pounds to 150 pounds per square inch, single grate areas, 4 feet long, fore and aft, and 28 feet wide athwart ship, grates of 112 square feet area and fired with 2 tons of coal per hour. The writer once constructed a number of locomotive engines to burn anthracite coal, and the firebox entirely behind the wheels, and spanning a 6 feet gauge railway, was 7 feet 6 inches wide inside and 6 feet long in the direction of the tubes, thus presenting the enormous area of 45 square feet.

"Engineering" concludes that if the crown plate of a firebox were 10 miles square, there would be no difficulty whatever, as long as the boiler was properly supplied with water, in keeping it covered.

THE PRODUCTION OF OIL FROM COAL.

When shale or coal is submitted to distillatory treatment, the most volatile portions at first escape, leaving behind substances of continually decreasing volatility. As the operation proceeds, and on an increase of temperature, these are evolved in a gaseous form unchanged, or resolved into more volatile matters and residual products possessing a still greater fixity. These products vary in nature with the temperature to which the coal is exposed, and when it is distilled at a red heat it yields a large quantity of gaseous and but a small amount of liquid hydrocarbons. The proportion of liquid products is much greater at a lower temperature. Coal-tar obtained from the distillation of coal contains various basic substances, including ammonia, aniline, diculine, chromoline, pyridine, toluidine, and others possessing less importance. The acids include acetic and rosalic, among others, but the principal acid is carbolic or phenic.

The first products from the distillation of the tar are gases, then follow water and ammoniacal salts, with black oily matter. As the process continues, the proportion of watery products decreases and that of oil increases. The products become heavier than water when from 5 per cent. to 10 per cent. of the original quantity has passed over in the form of light oil. It must be remembered that as the light oils disappear from the still, the remaining substances become more fixed, and a higher temperature is required for heavier oils. As the products increase in density, creosote, or "dead oil," appears, naphthaline and other solid products then become abundant, and the oil assumes a viscid state; the final residue constitutes asphalte if the distillation be carried to a sufficient extent.

The light oils on rectification can be made to produce a still greater portion of heavy oil and crude naphtha. The heavy oils contain a number of hydrocarbons of high boiling point. If the crude naphtha be agitated, the supernatant liquid on rectification gives rise to highly rectified naphtha, containing at least 4 or 5 oils, with specific gravities ranging from .860 to .890, and with boiling points from 149° to 392° Fahr. The watery liquids produced in the condenser during the manufacture of gas are employed for the production of sulphate and chloride of ammonium by a process of concentrating, crystallizing, and sublimating the crystals.

At the Ardsley Works, the retorts are 50 in number, and of an oval form. They are arranged in 2 sets of 25 each. Each retort weighs about 2½ or 3 tons, and contains from 10 to 15 cwt. of coal. The crude oil from the retorts is pumped into the stills, 3 in number, each having a capacity of 1,500 gallons. A small fire is placed under the stills, but the chief part of the heat is communicated to the body of the oil by means of superheated steam in a wrought-iron pipe entering the top of the still and carried nearly to the bottom, where it forms a coil, which is perforated with small holes; steam is thus blown into the body of the oil. The amount of water introduced into the oil by the condensation of the steam is inconsiderable, and is readily separated. The distilled oil is collected in a tank from a coil laid in a cistern of cold water in the usual way.—*Mechanics' Magazine.*

ANCIENT ROMAN MASONRY AND MORTAR.

A paper on this subject, by Mr. Spiller, F. C. S., read before the last meeting of the British Association, says: A more than antiquarian interest attaches to the remains of Roman constructive works in England, as they appear to have withstood the ravages of time better than the Norman and mediæval monuments of a later period. The walls of the Castrum of Burgh, Suffolk, are of rubble masonry, 6 feet thick, faced with flints and layers of red tiles. The stones are large, and the mortar reddened by pounded brick. Although the structure is estimated to be 1,500 years old, one wall, with a gate in the centre, is still perfect throughout its length—650 feet. The following chemical points are discussed:

1st. To what extent the hydrate of lime becomes recarbonated by exposure to air?

2d. What is the physical candition of the carbonate so produced? and

3d. Whether in this long interval the silica and lime can directly unite with each other?

Different views on this subject have been advanced, the prevailing opinion undoubtedly being that the lime never becomes thoroughly recarbonated, but stops short at a point when a definite combination of hydrate and carbonate of lime is formed; and, secondly, that lime is endowed with the power of attacking sand and other forms of insoluble silica by long contact at the common temperature.

The conclusions of the author are, that the lime and carbonic acid are invariably united in monatomic proportions, as in the original limestone rock; and that there is no evidence of the hydrate of lime having at any time exerted a power of corroding the surfaces of sand, flint, pebbles, or even of burned clay, with which it must have been for lengthened periods in contact. Further, that the water originally combined with the lime has been entirely eliminated during this process of recarbonation; and, this stage passed, the amorphous carbonate of lime seems to have become gradually transformed by the joint agency of water and carbonic acid into more or less perfectly crystallized deposits or concretions, by virtue of which its binding properties must have been very considerably augmented.

Analysis of the Roman mortar and of the red bricks, or tiles, gave the following results:

Roman Mortar from S. E. Tower, Burgh.

	I.
Sand	54.50
Soluble silica	0.40
Red brick with some unburnt clay	18.00
Carbonate of lime	25.75*
Sulphate of lime	0.15
Carbonate of magnesia	0.08
Chloride of sodium	0.05
Magnetic oxide of iron	traces
Wood charcoal	traces
Water, chiefly hygroscopic	0.92
	99.85

Samples of Burgh Mortar.

	II.	III.	IV.
Sand and brick, with a little unburnt clay	72.3	71.4	67.0
Carbonate of lime, etc. (by difference)	27.7	28.6	33.0

Samples II. and III. taken from the south wall. Specimen IV. from the north wall.

Red Brick or Tile from S. E. Tower, Burgh.

Silica	72.7
Alumina	14.0
Peroxide of iron	10.0
Lime	2.1
Magnesia	traces
Oxide of manganese	traces
Loss	1.2
	100.0

STEEL-HEADED RAILS.—The Montour Iron Works at Danville, and Cooper and Hewitt at Trenton, are producing puddled steel-headed rails of good quality, and filling large orders.

* Found, lime 14.5, carbonic acid 11.25 per cent.

IRON STEAMSHIPS AND HOW TO BUILD THEM.

The days of wooden hulls and sailing vessels are numbered. The iron hull, properly constructed, outlasts, perhaps, half a dozen wooden hulls—the first iron ships, if not running to-day, were only broken up because they were too old-fashioned. The iron hull greatly increases strength, durability, carrying room, and capacity for fine lines, heavy enginery, and consequent high speed, with a given displacement. And regularity of arrival and departure, and the consequent economical regulation of all associated business transactions, have rendered steamships preferable to sailing ships, even to carry coal, which of all freights can afford to wait. Wind costs nothing, but time is money, and steam and time, like power and heat, are convertible terms. Few if any sailing or wooden vessels are building in Great Britain, and our leading constructors and merchants admit that iron steamship building must be the leading feature in the resurrection of our ocean supremacy.

The history of iron ship-building in Great Britain is full of instruction, and if our builders are wise, they will profit, not only by the mistakes, but by the talent and experience of European constructors. The early iron ships were well built, of plentiful and good material, but not with the greatest economy of it, and many of them are running to-day. Their wonderful endurance in sea-ways and on lea-shores is proverbial. Afterwards the business was overdone, just as locomotive building was in this country a few years ago, and as a result cheap and bad work; *Royal Charters* and *Connaughts* were put afloat to the peril of money as well as life. And at last science came to the rescue; less material is so placed as to insure greater strength, and people are beginning to pay good prices and to get good work out of good ships. The successful transatlantic companies do not go to second-class builders; they cannot afford to run cheap ships.

There are no second-class iron ship-builders in this country yet, and this is the promising feature of the enterprise. If our builders never turn out bad work, they and our merchants and the public will be vastly the gainers in the end. We can better postpone iron ship-building another decade than to lower the standard of American work.

And still greater reforms and improvements must be introduced. Thick plates and costly material, piled into places where they cannot work, must be abandoned. A rib placed where it can receive a maximum strain, costs no more than a rib placed where it is merely dead weight. A ship is primarily a beam. As a beam it receives every strain of the sea. Now, a bridge or any girder made up of a thin, light web, running from end to end, and great vertical parts without longitudinal connection, would hardly sustain itself. Yet a ship so constructed is expected to hold up the enormous weight of its unsupported ends every time they overhang the trough of the sea, and of its partially supported middle every time the ends are buried in the waves—a constant and powerful vertical and lateral strain upon every joint in the hull. The great strain on a ship is the perpetual pulling apart and shutting together of its bottom and deck in a longitudinal direction, and yet the greater number of iron ships have been built without sufficiently strong bottoms and without any top strength except their sides. Many ships have first broken apart at the top sides and then gone to pieces. Heavy, continuous iron decks along the sides have partially remedied this evil. But the grand reform in this direction is to make the frames, the *ribs* of the vessel, longitudinal instead of vertical. Now, they are chiefly studs upon which to nail the siding. By making them continuous from end to end, they perform every present function and add their enormous strength *in the direction of the greatest strain.* Some genius has objected to the longitudinal rib system because the ribs of fishes are vertical. But while the rolling top of the sea forms a constantly varying support for a ship, a fish swims in a uniform medium that would not bend a reed—not on the water, but under it—and it has been observed that ships built like fishes have a tendency to do the same thing.

If our iron ship-builders will place our superior iron only where it can work, so as to use less of it, they can at once and successfully compete with foreign builders in cost and quality, and so revive not only our workshops, but our merchant marine.—*New York Times.*

PRESERVING TIMBER.

The chief cause of the decay of timber lies in the fermentation or decomposition of the albuminous matter contained therein. This matter may be neutralized by chemical agencies, as by the well-known processes of Burnettizing, Creosoting, etc., or it may be coagulated and destroyed by heat, which also hardens the wood. The charring plan is, however, for obvious reasons inapplicable for general use. The albumen may also be expelled or nullified by thoroughly steaming the wood.

Says the "American Artisan": Where time can be allowed therefor, it will be found quite efficacious, and more economical, to saw the timber to sizes but little larger than those to which it is to be wrought, and then place it, for a few weeks or months, in a stream or pond, where the water will gradually dissolve and wash away the nitrogenized or albuminous substances. The wood must then be thoroughly dried slowly, as a too speedy expulsion of the moisture would be apt to induce checking; the ordinary method of piling the stuff is, however, sufficient, the pieces of timber being kept at slight distances from each by suitable intervening strips, and the whole, when possible, protected from the sun and from strong currents of air. Inasmuch as the moisture will pass off less readily as the pores at the surface of the wood become closed by drying, it is well to complete the seasoning system by a process of kiln-drying, which at this stage will not check the timber.

The method of creosoting timber, which was lately invented by Professor Seeley, of New York, consists of subjecting the wood to be saturated to a temperature of about 230°, while in a bath of creosote oil, for a sufficient time to expel all the moisture, and to coagulate the albuminous matters of the wood. When the pores are thus freed from the water, and contain only steam, a cold bath is substituted, so far as to reduce the temperature from 230° to 65° or 70°, by means of which change the steam in the pores of the wood is condensed, and a vacuum formed, into which the oil is forced by an atmospheric pressure.

The process, says the "Detroit Post," has all the advantages of the method which has been in use in England and on the Continent for many years (and experience has demostrated that creosoted timber is still sound after being in use more than 22 years), and is much more simple in its application, and consequently more economical and expeditious than the English process.

Among the advantages claimed is the very important one that green wood can be treated as successfully as dry. The apparatus for creosoting, which has already been shipped to the Flats, and is now being erected on the dikes of the canal, was built in this city, and consists of a cylinder 45 feet long and 8 feet diameter, with a steam coil in the bottom and a movable head. The cylinder rests upon substantial timbers, and when the head is removed the lumber is run into the tank upon trucks. In addition, there are 2 receiving tanks for oil, each 15 feet in diameter and 6 feet high, with engine and boiler, connecting pipe, pumps, etc.

It is expected that this process will be applied to the timber to be used in the government works about to be begun at Toledo. Mr. Pelton has also similar works now in successful operation at Chicago for treating railroad ties and dock timber.

The Chicago, Burlington, and Quincy Railroad Company are preserving all their sleepers. They have at the Aurora shops a tank of boiler iron 10 feet square and 7 feet deep. This is filled with ties and closed with a tight cover, when carbolic acid sufficient to cover them is let in, and raised to a temperature of 245° by the application of steam. Here the ties remain for 30 hours, at the close of which they are thoroughly permeated with the carbolic acid and become as black as charcoal.

As to the duration of creosoted sleepers, the "Railway News" says: According to experiments and accurate records kept in Germany, sleepers of uncreosoted or natural oak last, upon the average, 15 years. By creosoting or impregnating them with other preserving substances, they endure for upwards of 22 years. From the same authority we learn that creosoted fir sleepers have a duration of about 13 years, while pine and beech will not last longer than 9. The lighter description of traffic prevailing over the German lines, which have furnished the above results, is the real cause of the sleepers lasting so long. It is needless to remark that upon our heavily worked railways they do not enjoy so long a life, but succumb, in the majority of instances, to wear and tear in about half the time, and in many instances much sooner.

LIQUID FUEL—DORSETT'S SYSTEM.

RESULT OF EXPERIMENTS ON THE STEAMER RETRIEVER.

This system of burning liquid fuel under boilers, says the "Mechanics' Magazine," is extremely simple in its details; it consists of a generator, which is nothing more than a small portable vertical boiler, in which the creosote is vaporized under a pressure of from 35 pounds to 40 pounds (932°), the vapor being led through a pipe to the furnace of the steam boiler, under which it is burned in jets.

In the trial of this system on the steamer Retriever, of 90 nominal horse power and 500 tons burden, there were 2 of these generators, which were placed on the deck of the vessel against the boiler casing, the pipes being carried down from them to the boiler furnaces. The creosote is pumped into the generator, a shovelful of live coal is placed under it, and as soon as the vapor begins to distil over, it passes down a pipe into the furnace of the generator. There it issues from perforations in the pipe, and continues the duty commenced by the coal, and supplies the vapor to the boiler furnace.

The adaptation of the coal furnace of the Retriever to the purpose of burning liquid fuel was effected by removing the furnace bars and filling the ash-pit with two layers of perforated fire-bricks. The apparatus is more fully described in "Engineering" as follows: About 3 inches above the floor of each ash-pit is placed an iron plate, which extends the full length of the furnace, and is curved slightly upwards at the inner end, where it projects into the return box. At a distance of 3 inches above this plate is placed another shorter plate, this latter being perforated, and being covered with a layer of fire-bricks placed loosely on it. At the front end the space between the 2 plates is closed by perforated bricks, which admit a certain supply of air, and at the inner end it is blocked up altogether, so that any air entering through the perforated bricks just mentioned can only find its way into the furnace by rising through the perforations in the upper plate and through the interstices of the layer of bricks by which that plate is covered. The air passing in between the lower plate and the bottom of the ash-pit is conducted right through into the return box for the supply of the jets of vapor placed there, and the amount thus admitted is regulated by closing the front of the opening to a greater or less extent.

The branch pipe led into each furnace makes a single long convolution just above the layer of bricks already mentioned, and then returns to the front of the boiler, and is connected to another pipe which is provided to discharge any creosote, etc., which may condense in the pipes. Each pipe is provided with independent inlet and discharge cocks. Each of the pipes in the furnace is pierced with 4 holes rather more than $\frac{1}{16}$ inch in diameter, and the pipe carried transversely through the return box is pierced with 8 similar holes, these being placed, 2 opposite the end of each furnace, and 1 over each of the water bridges between the furnaces. The boiler is thus heated by 20 jets altogether, of which the set of 8 in the return box, or each set of 4 in the furnaces, can be worked independently. When the vapor is first turned into the pipes a portion of it is of course condensed, and this portion is blown off through the discharge pipe already mentioned. As soon as the pipes become heated the discharge cock is closed, and it is afterwards only opened occasionally to get rid of any liquid that may have accumulated in the pipes.

During the preliminary trip of the vessel, the steam was maintained at the usual working pressure, and it was stated that the vessel made 1 knot more per hour than she had been accustomed to make with coal. The consumption of creosote was between 35 and 40 gallons per hour, as against 8 cwt. of coal, and considering that the present price of creosote is only about 1 penny per gallon, a great saving was apparent.

The official report of Dr. Paul on a subsequent trial trip, contains the following facts: The duration of the trip was 4 hours and 35 minutes. The oil weighed 10.5 pounds per gallon; the weight of oil consumed was 2,416.4 pounds or 1.078 tons, the average rate being 527.6 pounds (= 50.25 gallons) per hour. Experiments on the rate of vaporization of water showed the rate to be 12.3 pounds heated from 60°, and converted into steam at 212° per pound of oil. During the trial very little smoke was produced, and during great part of the time none at all. The temperature of the furnace gas passing into the funnel ranged from 250° to 350° C. (= 482° to 662° Fahr.), or, on the average, about 572° Fahr., and, as the external atmospheric temperature was about 50° Fahr., the waste of heat in the discharge gases corresponded to an increase of temperature to 522° Fahr. above that of the air consumed in feeding the furnaces.

For the purpose of arriving at some approximative estimate of the extent to which the result obtained in this practical trial corresponds with the actual evaporative power of the material used, Dr. Paul calculated theoretically the amount of heat it is capable of generating, and the maximum effect to be expected from its application under the ordinary conditions obtaining in practice. So far as the chemical nature of dead oil is known, it is a mixture of several substances—such as phenol and cressol, which contain, besides carbon and hydrogen, some oxygen, together with a variety of hydrocarbons, such as naphthaline, xylol, cumol, cymol, and perhaps others. According to the chemical composition of these substances, and on the assumption that the combustible carbon and hydrogen they contain will generate when burnt with just sufficient air for perfect combustion, quantities of heat sufficient for converting respectively 11.359 pounds, and 41.895 pounds of water at 60° into steam at 212° Fahr. for each pound of carbon or hydrogen burnt, when allowance is made for the heat rendered latent by the vaporization of the water resulting from the combustion of the hydrogen, and for the waste of heat due to the furnace gas being discharged at a temperature of 600° Fahr. above that of the air supplied to the furnace for combustion, the theoretical evaporative powers of these substances, and the evaporative duty they are capable of effecting will be as follows for 1 pound weight of each:

	Evaporative power. lb. of water at 212° Fahr.	*Evaporative duty. lb. of water at 60° Fahr.*
Phenol	12.2437	10.5025
Cressol	13.0096	11.1632
Naphthaline	15.4635	13.2675
Xylol	16.5866	14.2415
Cumol	16.7838	14.4126
Cymol	16.9422	14.5500

The result thus arrived at on theoretical grounds presents a very striking approximation to that obtained on the practical trial on board the Retriever on October 23d, viz., 12.356 pounds for the evaporative duty, which is only .667 less than the maximum duty indicated by calculation. If it be correct to regard the composition of dead oil as represented above, this approximation between theoretical and practical results would indicate that the application of liquid fuel, according to Messrs. Dorsett and Blythe's system, insures not only a very perfect combustion of the oil, but also a very full utilization of the heat generated. The very small amount of smoke produced during the trial would involve some waste of heat, and would to some extent account for the difference between the two results; but it must be remembered that in the trial the average temperature of the furnace gas discharged into the funnel was only 572° Fahr., or 522° Fahr. above that of the air supply, while in the calculated result it is taken as being 600° Fahr. above the air supply; so that in the practical trial there was a more efficient and economical application of the heat generated than has been assumed in the calculation.

A still further economy of the heat generated might be effected by heating the air supplied to the furnaces by the waste heat passing away into the funnel, and it is probable that in this way the combustion might be regulated and rendered so perfect that there would not be any waste of heat arising from smoke. These considerations lead to and justify the presumption that when the various appliances for burning liquid fuel according to this system shall have been more thoroughly perfected and adapted to the conditions and requirements of steam navigation, an evaporative duty of 13 pounds per pound of oil burnt may be realized.

But having regard only to the result actually obtained at present, it will be seen that the evaporative duty realized in the trial is about 100 per cent. greater than that ordinarily obtained with an equal weight of coal in steam vessels—that is to say, a duty of about 7 pounds per pound of coal consumed. Therefore the weight of oil required to fuel a vessel would be only one-half that required of coal, or the weight of fuel to be carried would be only one-half as much as when coal is used. Then taking the ton of coal as stowed on board a vessel to occupy 43 cubic feet and the ton of oil as occupying 34 cubic feet, the quantity of oil equivalent to 1 ton of coal, would occupy only 17 cubic feet, so that the saving in stowage space would amount to 60.4 per cent. of the space required for coal.

CONSTRUCTION OF LOCOMOTIVES IN GERMANY.

BY M. S. STUTZ, C. E.

Translated from "*Annales du Génie Civil.*"

From the date of the Universal Exhibition of 1855, where for the first time they saw German locomotives, the attention of French engineers has been awakened and drawn towards a particular class of these engines. Since then the Germans have made further progress, as the Exhibition of 1867 has proved, in showing us a series of locomotives, the elegance and finish of which excited general remark. The general design of these machines has been sufficiently described by Mons. Jules Gaudry, engineer of the Eastern Railway, in the *Studies in the Exhibition of* 1867, where our readers can find full accounts of them. What we now propose to consider are certain new dispositions and details, which constitute a real progress; and in this we shall avail ourselves of a report read by Mons. De Leoben, in a reunion of the engineers of the district of Stettin.

The German engineers have labored to reduce the construction of locomotives to the utmost simplicity, especially the mechanism for the distribution of steam. From this has resulted a general disuse of separate expansion valves. On the other side, there has been a disposition to make new trials of balanced valves; the results of which appear very satisfactory.

The application of the simple link of Stephenson has become general; excepting some cases in which Allan's straight link is used. But still the valve gear of Heusinger de Waldegg is often used. In this the link is worked on a fixed centre by one eccentric; and the lead is taken from the cross-head. The two first produce by a single valve with sufficient lap, a variable expansion that is regarded as satisfactory.

There is a tendency to substitute the screw for the simple reversing lever and catch-plate. A screw, one-half which is right and the other half left, is used. The right part works in a fixed nut, so that the screw advances as it turns; and the left part works in a nut to which the reversing rod is jointed, so that this nut travels twice as fast as it would if a single screw of the same pitch were used. Four turns of the screw are sufficient to reverse an ordinary engine.

For feeding, the injector is more and more superseding pumps, even independent steam pumps. Its advantages are that it works with certainty, and needs no repairs. Herr Krauss, constructor, of Munich, has reduced this instrument to extreme simplicity. The water flows in a straight line from the tank into the boiler. There is no movable cone to regulate the influx of water; nor is there any movable coned needle to regulate the admission of steam. The steam nozzle enters the water chamber, and bends into centre line at the point best for general working, and thus the whole instrument is solid; all its parts are immovable, and there cannot be derangement from wear of packing, or other delicate and costly adjuncts of the original injector. It is screwed into the fire-box behind, and the water is spread around by the flat disc check valve inside, so that it does not flow against the fire-box plate. A cock close behind the water chamber shuts off and regulates the flow of water; and a stop valve at the boiler regulates the admission of steam, and the instrument itself is almost as simple as a cock. To start it the water cock is first opened, and then the steam is admitted gradually, after which the admission of water and steam can be regulated as required by the cock and steam valve. But it will not draw up the water; the tank must be above the level of the injector, so that the water will flow in by gravitation. The usual place for the injector is under the foot-plate.

It remains to observed that the modification of Herr Krauss' permits of feeding with hot water, an advantage which the first injectors rendered impossible.*

As to the boiler, the junction of the barrel with the fire-box shell, formerly made by an angle iron ring, is now made directly, as making the surest and tightest union. For this purpose the front plate of the fire-box shell is flanged to receive the barrel. The flanges are sharply turned. To provide ample steam room, and to facilitate the cleaning of the crown sheet, the outer crown is raised 12 to 16 inches above the barrel.

The pressure is generally $8\frac{1}{2}$ atmospheres, sometimes 10 atmospheres, on the gauge. It is subjected to severe supervision, by the aid of special manometers which show exactly how high the pressure has been. The manometers are patented by Herr Sammann, an engineer of Breslatt, and manufactured by Grutzmacher & Bock, of Magdebourg.

In the construction of fireboxes only copper plates are now used. Iron fireboxes are completely abandoned, on account of numerous inconveniences they involve. These inconveniences, it was hoped, would be avoided by using cast-steel plates, which might bear the pressure better; but the trials made have given results that are but little satisfactory. The inequality in the manufacture of these plates, which are too hard and brittle or too soft, is, without doubt, the cause of this failure. But notwithstanding the ill success, several German and Austrian companies, for the sake of diminishing the weight of their engines, persist in using cast-steel plates for the construction of boilers.

The iron boilers are made of plates .45 minimum and .62 inch maximum thickness; while the thickness of the cast-steel plates varies from .32 to .4 inch. For pressures above $8\frac{1}{2}$ atmospheres the lengthwise joints are double riveted.

The staying of the firebox, especially the crown of it, merits the greatest attention. Besides the ordinary stays of the crown, there are 4 rods which link together the front and back plates, and 8 long rods from the back plate to the smoke-box plate. This mode of staying has always given perfect security, and never needed repairing.

The use of hollow stays for the sides of the firebox has given excellent results, and is becoming general. The perforation is an easy and sure means to detect the rupture of stays, and generally gives warning of decay before it results in rupture. To provide for cases of rupture, it is necessary to stop the holes at the inner ends, so that steam or water may not enter the firebox, and extinguish or slacken the fire.

In putting into practice this idea of perforating the stays, some difficulties were met, consisting chiefly in the drilling of very small holes, .12 to .2 inches diameter, and the whole length of the stays: but an entirely satisfactory solution was found in a machine which drilled from the ends to the centre, thus shortening the drills, and also shortening the time necessary for the work. The stay is held in a hollow arbor between the two drills; the arbor turning 380 times per minute, while the drills turn in the opposite direction 680 times, making a total speed of 1,060 turns per minute for the drilling. With this machine a man drills 70 to 80 stays per day. The machine consists of a lathe bed, on which the bearing of central arbor is fixed, and the two drilling arbors are made to traverse by a right-and-left screw.

Another convenient tool is used to cut off the ends of the stays after they are screwed in. It has two cutting knives or chisels, one of them fixed, the other moved up to its work by a screw. A washer is put on the end of the stay, to determine the length; the tool is then put on, and pressed up to the washer; the screw is then turned by a hand-lever, and the cutters approach each other, cutting off the waste end. One man cuts with this tool more than 3 men can cut in the old way, and there is no blow or strain to injure the work.

In the manufacture of tubes iron is

* Mr. James Millholland, 8 years ago, patented a modification of the injector even simpler than this. It had no break or opening between the water jet and the throat, so that there could be no overflow when too much water or too little steam was admitted. An overflow cock between the throat and the check-valve was provided to start with.

now much used. These tubes have thus far given good results. Their outside diameter is from 1.28 to 2.08 inches. The joints at the tube plates require always great care. Several trials of cast-steel tubes have given equally good results, and they allow a reduced thickness.

The wheels are generally of wrought-iron, in one piece, with the boss and counterweight. The tires are of cast-steel. Notwithstanding several cases of rupture during the extreme colds of winter, the results of cast-steel tires, in durability and economy, leave little to be desired. The use of steel less hard and brittle, in cold climates, will certainly prevent ruptures.

The forges of Borsig, at Berlin, have acquired a high reputation in Germany for the manufacture of wrought-iron wheels. And so with the steel tires from the Works of Krupp, at Essen, which have furnished enormous quantities for all parts of the world.

Disc wheels with circular corrugations are frequently used on tenders. They are of cast-steel, in one piece, tire included. They have certain advantages as compared with other wheels. They are made by the Company of Mines and Steels of Bochum in Westphalia.

It is necessary to observe that these wheels, like those with steel tires, have inconveniences as well as advantages. It is necessary to true the tires or rims that have lost their shape. To do this, instead of turning them, the Cologne and Minden Railway Company use grindstones. The wheels are put in a lathe, and made to turn slowly, about once per minute, while a grindstone turns against the rim about 500 to 800 times per minute, according to its diameter: 500 turns for a diameter of 25 to 30 inches. The stones are coarse-grained, about 4 inches thick. They work best dry; but when used dry, it is necessary, for the health of the men, to use a fan to blow away the dust.

The axles of the German engines are all of cast steel; so are the connecting-rods, and generally the coupling-rods, and also the other chief parts, as the engines of Borsig have shown us. Steel allows great reduction of dimensions, and the attainment of extreme lightness—an essential condition, especially for high-speed passenger engines.

The pistons are of wrought-iron, forged on the Swedish system, often in one piece with the piston-rod. Two packing rings are used, sometimes of cast-iron, sometimes bronze. A counter piston-rod (contre-tige) is frequently used. These counter-rods are sometimes of cast-steel, and forged solid with the piston.

The speed of pistons varies between 6.4 and 8.8 inches per second. Though this speed is far from the maximum, it is rarely exceeded up to this time.

The question of the lubrication of valves, also of pistons, has much occupied engineers; and has been practically solved by the system of Kesler. This system, which works automatically, and very regularly, is applicable to many uses, and appears to save a third of the oil, while it insures abundant lubrication.

The diameter of steam cylinders is from 13 to 20 inches. The length of stroke is from 20 to 25 inches, and rarely attains to 28 inches. On these dimensions, that is, on the volume of steam used in a given time, depends the force of the engine. Very intimately connected with the cylinders, relatively to the work to be done, or that which comes to the same thing, the quantity of steam to be used, is the heating surface which produces the steam. The surface is made as large as possible, and varies between 914 and 1,882 square feet of which $\frac{1}{10}$ to $\frac{1}{18}$ is fire box surface.

The grate surface, generally arranged for common coal, is equal to from $\frac{1}{65}$ to $\frac{1}{90}$ of the heating surface. For wood the grate surface is still larger.

Among the numerous inventions to burn smoke, that of Tembrink-Bonnet has had many applications; and has given good results, especially when the feed-water has been good. Thierry's system has equally been applied. But no decision has been made, relative to the general application of these systems.

A good disposition of the chimney, relative to the draft, to stimulate the generation of steam as much as possible, is very important. To this effect the system of Prussman, composed of two truncated cones united at their small ends, is frequently applied. This seems much like the blast pipes in many English engines.

As to the weight on driving wheels, it

is admitted generally, for rails 5.2 inches high by 2.4 breadth of head, that 13 tons (13,000 kilog.) should be the maximum weight for axle; consequently the number of coupled wheels, whether 4, 6, or 8, to utilize the weight for adhesion, constitute the foundation of the power of the engine; that is, they determine the loads that can be drawn up the grades that have to be surmounted.

To couple more than 3 axles, or 6 wheels, does not appear very practical, on account of the too many joints between them, giving rise to complicated construction, and the liability to rapid wear on short curves.

Some constructors have renewed the attempt to utilize the total weight of locomotives for adhesion; and with this view they have constructed engines with only two axles. In this plan there are great difficulties to be overcome, which will ever remain a serious obstacle, above all to freight engines, in which it is required to obtain a maximum of weight for adhesion.

Tank engines do not appear to be economical, except for short lines, or for switching. The diminution of weight as the water and fuel are consumed renders them extremely defective for long lines.

A system of construction of locomotives very frequently followed of late years, deserves to be mentioned here. We speak of the system of Hall, which is distinguished by putting the frame plates outside the wheels, instead of inside, as in usual practice. This disposition gives room for a wider firebox, and allows the boiler to hang lower, and to rest on a wider spring base than usual; the two last are important advantages, since they insure a steadier movement by avoiding lurches.

Among the objections to this system, it is urged that the diameter of the axles must be augmented, and that the overhanging ends have considerable weight, and that the axle-boxes are heavier, and that, as these parts act directly on the rails, without the intervention of springs, this increase of weight is the more injurious. Also the outside cranks, whose hubs, lessened in diameter, extend inward and serve as journals, offer difficulties; and, altogether, there is little confidence in the surety and solidity of the construction. But these inconveniences do not appear well founded beyond a certain point.

As to the outside crank, the Universal Exhibition showed some modifications of it, by the Meyers, engineers of Mulhouse, which offer the best solution of this inconvenience, objected to in Hall's Meyer forges the outside crank solid on the axle, and makes the eye of the wheel so large that the crank can be put through it.

The widths in these engines are as follows for German railways: For 6-coupled freight engines, between the centres of wheels or rails, 60 inches, between the frame-plates or springs, centres, 71.68 inches; between cylinder centres, 93.28 inches. For passenger engines with independent wheels, between wheels and frames the same as above; between cylinder centres 86.88 inches.

Several other systems to ascend steep grades have been tried. We observe among them a disposition having some analogy to the chain warping on the Seine. It consists in laying between the rails, for the whole length of the incline, a strong plaited rope, which winds around the driving axle, (a separate axle specially for the rope?) in the same way as in the warpers. The rope in unwinding resumes its place between the rails, and may serve for several trains at a time.

A more advantageous arrangement, though very complicated, to increase the adhesion, is that after Fell's system which is in practice on Mount Cenis. In this system a third rail, raised higher than the two others, is placed between them, and four horizontal driving wheels, two on each side, are strongly pressed against the middle rail by spiral springs.

The engines with 8 and 10 coupled wheels, with the front group movable sidewise, of the system of Ergerth, Fink, and Hall, constitute also a powerful means often employed to ascend very steep inclines.

From what has preceded, it results that the good arrangement of a locomotive having sufficient boiler, and cylinders and wheels well proportioned, must be judged by the relation existing between the total weight and the weight utilized for adhesion. This condition is essential for freight engines that draw heavy trains, in which all weight not utilized for adhesion is dead weight to be carried or drawn.

The following table gives the principal dimensions of the weight of German locomotives, which by their good results merit a report here :

	6-coupled.	4-coupled, One Axle in Front.	Mixed, 4-coupled, One Axle Behind.	One Pair Drivers.
Diameter of cylinder...	17.8 in.	16.2 in.	16.2 in.	15.68 in.
Length of stroke.......	25.12 in.	25.12 in.	23 in.	20.92 in.
Pressure..............	8½ at.	8½ at.	8½ at.	8½ at.
Heating surface........	1268.5 ft.	942.75 ft.	847.1 ft.	953.5 ft.
Diameter of wheels.....	50 in.	56.4 in.	73.2 in.	80.16 in.
Speed, miles per hour..	14	18.6	27 to 37	47 to 56
Weight on drivers	37½ tons.	24.4 tons.	18.5 tons.	13 tons.
Total weight.....	37½ tons.	31.2 tons.	29.5 tons.	29.5 tons.

The 6-coupled engine can draw on a level 1,100 tons at 14 miles per hour. It has axles and tires of cast-steel; wheels, rods, and tubes of wrought-iron; firebox of copper; and costs about 69,000 francs. The 4-coupled, with leading wheels independent, can draw 650 tons at 18.6 miles per hour on a level. The axles and tires, etc., are like the one above, and it costs 63,500 francs. The mixed 4-coupled, with trailing wheels independent, can draw 350 tons on a level at 27 miles an hour. Parts of the same material as the foregoing, except the coupling-rods, which are made of cast-steel, on account of their great length. The engine with a single pair of drivers, can draw 150 tons at 47 miles an hour. Axles, tires, and rods of cast-steel: cost 62,000 francs.

GENERAL McCLELLAN is to complete the Stevens Battery for the State of New Jersey, as provided for in the will of the late Edwin A. Stevens.

PUDDLING MACHINES—RESULTS.—Up to the present time, as we are informed by Mr. Menelaus in papers read before the Society of Mechanical Engineers, the results of mechanical puddling are unsatisfactory, inasmuch as the iron produced has been cold-short, and unfit for use. This failure is attributed by Mr. Menelaus to the breaking up of the lining of the furnace. The suggestion was made that the uniform quality of the iron produced with differing linings pointed to some other cause; but, as far as we know, no suggestion was made as to the direction in which to seek the cause of failure.

The one chief feature in successful puddling on the present plan consists in protecting the molten iron from the direct action of the flame by a supernatant mass of molten scoria, whereas in the revolving puddling furnace the iron would appear to be lifted from beneath the scoria into immediate contact with the flame. It would be reasonable, therefore, to expect an appearance and quality similar to what is known as burnt iron.—*The Engineer.*

MAGNESIA CRUCIBLES.—The great and constantly increasing cost of crucibles, is the greatest obstacle in the way of the crucible steel manufacture in this country. A patent has been taken out in France for making crucibles to melt platinum, iron, or steel, from magnesia. The description given is not very clear; but we believe they are moulded by pressure, and are then exposed to the heat of an oxy-hydrogen flame, by which they are brought to a semi-pasty condition, and the magnesia acquires its greatest density, cohesion, and hardness. Such crucibles are said not to be affected by sudden alterations of temperature.

UNEMPLOYED MOTIVE POWER.—The "American Artisan" calls the attention of inventors to the great powers that are, so to speak, going to waste—among them wind and tide. The want is, efficient mechanical appliances—the power is almost infinite. Captain Ericsson, has attempted the utilization of what would seem to be a more impracticable motor still—the direct heat of the sun, but with great promise of success.

BUILDING AND FACING WITH CONCRETE.

Translated from La Houille for the London Colliery Guardian.

The walling of the sides of shafts in places where the rocks are not sufficiently solid, or possessed of sufficient resisting power, is commonly composed of either stone or brick. During recent years various parties have begun to make use of conglomerate concrete, a purely artificial material, for building, which is simple as regards the process of preparation, and easy to be used, while at the same time presenting a great resistance and perfect impermeability, which latter quality renders it extremely valuable for works that are in contact with water. Amongst the structures raised of late years presenting a certain amount of importance, and in which the conglomerate concrete has been employed, we may specify many buildings at St. Denis, the drains of the new Opera House, the Church of Vesinet, the vaults of the subterranean galleries of the Exhibition, the breast wall of the Avenue l'Emperor, from Pompe to the lamp beyond the Military Bakehouse. At the present moment they are constructing with this concrete, to the height of above 15 metres, the sloping boundary wall of the ancient cemetery of Passy. The concrete used is a cement rather than concrete proper. It is composed by the very intimate mixture of the following elements in determined proportions, thus :

Large sand, very pure	4 parts.
Lime	1 "
Portland cement..........	$\frac{1}{2}$ "

Water $\frac{1}{10}$ of the total weight of the mixture.

Instead of making with the sand and lime a mortar in liquid batter, the preparer must reduce as far as possible the quantity of water, and subject the mixture to an energetic and prolonged course of trituration. By this trituration, notwithstanding the great reduction of the water, there is at length obtained a dusty paste, which, after a continued process of pounding, is brought into the state of very stiff plastic paste. This is poured out into a movable mould in successive and very thin layers, and subjected to very serious pugging. This pugging effects such an agglomeration that there enters into each cubic metre of masonry from 14 to 15 hectolitres of the mixture, while the mass itself acquires a considerable rapidity and intensity of hold ; so much so that some few days or even hours suffice to give it the consistency of stone. Now, as the work done one day becomes perfectly consolidated with that of the day before, it follows that the mass of masonry may be indefinitely extended, so as to form one actual block of stone which offers a perfect resistance to frost and heat. This concrete thus forms a veritable stone paste, to which, by means of moulds, all sorts of forms may be given, and which will not present any joint, but possesses throughout a solidity not otherwise attainable. In order that the conglomerate concrete may present all the required conditions of resistance and of serviceable usage, it is necessary that the preparation should be well made. It consists of the following process : 1st. The greatest part of the water contained in the common mortars as concrete must be got rid of. 2d. The substance must be homogeneously and intimately mixed, notwithstanding the elimination of the water, by being subjected to a trituration energetic, prolonged, and operating with compression. 3d. From this trituration there must result successively a condition of hard plasticity, a pasty powder, and then a dusty paste. 4th. Agglomeration is next to be produced by the action of a hard and heavy body operating on thin successive layers poured out in proportion into a mould. By fixing movable moulds on the actual masonry, which it is required to raise to a further elevation, we may indefinitely augment its mass, and obtain, so to speak, stone without limit which advantageously takes the place of hewn stone and brick. The concrete, set under favorable conditions, offers a great resistance to picking or wearing of any kind, and its resistance to crushing reaches to from 400 to 500 kilog. per cubic metre. With regard to its producing or net cost price, it will vary in different localities, and will mainly depend on the rate of wages for manual labor. We are persuaded that this concrete can be advantageously employed in mines, its imperviousness to water and its power of resistance suiting it even for bottoming in crossing watery strata. Shafts walled with concrete would resist better and for a longer time than those faced with stone or even brick, by reason of the intimate union of its constituent elements and of their adherence to the bare surfaces which require to be faced. The facing of galleries, the fixing of conduits for water and for air, may also be done in concrete, and any movements in the earth will only produce therein fissures that may be easily repaired and filled up again with the same concrete, which will at once become incorporated with the old mass. The facing of shafts especially may be effected with great facility and great regularity. It would suffice, in fact, to suspend from a certain special rope, well fixed over the middle of the shaft, a box with very smooth exterior sides, of the diameter to be given to the shaft requiring to be faced, and behind this they could pug the concrete. As soon as a certain elevation had been attained, they could raise the box, pug anew, and so continue until they had reached the summit of the structure.

THE LOCOMOTIVE BUILDERS MEETING, recently held in New York, will, it is hoped, lead to better results than the meeting of 1856. If the builders had carried out the ideas of price and pay they all agreed to in '56, they would not have met with the general disaster that befell them in the autumn of '57. It is for the interest of railway companies and the public that locomotive builders should have no excuse for turning out inferior work. The American builders have done vastly more than the railway managers, to reduce the working expenses of engines. They deserve a reward for so greatly improving the American Locomotive, and they should have an inducement to perfect it. But they must build cheap and old-fashioned machinery, if railway managers will pay for nothing better.

STEEL-COVERED AXLES.—It is proposed to heat old axles red hot and to cast steel rings upon their journals or upon the whole axle. The steel is expected to unite firmly with the iron, and to be sound enough to finish well. This result can perhaps be realized after some expensive experimenting. Steel rail ends have been successfully cast into the centre of steel ingots, at the Pennsylvania Steel Works.

RAILWAY ACCOMMODATIONS.

This branch of civilization, says the "New York Times," is advancing perhaps more slowly than railway safety. But it does advance. Smoother permanent way, high and ventilated car roofs, the equalization of load on spread and elastic trucks, better ballasting and less dust, sleeping cars in many of which one can sleep when sufficiently fatigued, compartment cars well upholstered, better motive power, and hence closer connections, and some improvements in ticketing and checking, are the actual and comfortable facts of to-day, instead of the almost chimerical dreams they were a decade ago.

But let no railway manager suppose that he has earned immunity for another decade. Great improvements are still to be made in railway accommodations. Ventilators, for instance, are all very well, but ignorant and careless brakemen opening or closing them without reference to temperature or wind, in many cases convert them into a nuisance. Nor should officious or selfish passengers be allowed to regulate these matters. Here a brawny lumberman throws open every sash and panel on the windward, to the peril of invalids and children. There a hypochondriac seals up every aperture, to the peril of the general health and temper. There should be in every train, for invalids, infants, and old women of both sexes, who have no lungs, a compartment, ventilated as far as compatible with the exclusion of that arch-destroyer—Draft. And there should be an officer charged with the ventilation of the train—an officer who can distinguish between atmospheres of carbonic acid and air, and who can appreciate a calorific change when he enters from the out-door temperature of 40 to the internal heat of 100. And the ventilation should be under his exclusive control. The brakemen who periodically rush through a train, shutting every aperture that was open and opening those that were shut, are wonderfully innocent of all thermal and atmospheric distinctions.

But the grand discomfort, as well as the awful peril of our railway appointments, is warming the cars by stoves. If the recollection of freezing feet and aching head all the long winter evening by the railway fireside, does not throw the reader into a cold sweat, the remembrance of Angola will. There is, perhaps, no developed plan that will keep the temperature of a packed car, with constantly opening doors, as regular and pure as that of a Fifth-avenue drawing room—never below 65° or over 70°. The genius of invention may be equal to the task, but we consider the conditions absurd. When travellers are used to it they will vastly prefer the natural temperature of the outer air, modified by shade and draft in summer, and by a little artificial heat in winter; they will prefer to adapt their clothing to such an atmosphere, *provided always the feet be kept warm*, rather than risk the foulness and local heats of an attempted drawing-room temperature. We find a positive enjoyment in breathing the crisp air of an October morning, when we bundle up our persons to resist it; but the same temperature in a railway car would set the women distracted.

Another error lies in the provision of unsuitable means of warming. The American stove heats the head, while the feet remain in a cold stratum constantly re-enforced from opening doors. The use of *tanks of hot water* under the feet, preserves the temperature of every part that cannot be adequately clothed, and mollifies the general atmosphere without poisoning it. Any feasible distribution of heated air, cannot prevent the universal misery of cold feet. The present system of running to the stove to toast them, and back again to escape the headache, is better than any system of moderate heating by stoves. The calorific contrivance, whatever it may be, must lie *under the feet*. And hot-water tanks, changed at water stations, would probably, in effectiveness, certainty of operation, cost, and expedition, excel all other heaters. Water is admirably adapted for this purpose. It has the greatest capacity of any substance for holding heat, and its fluidity renders it the easiest of all substances to handle. By means of little doors in the sides of the car, between the seats, a couple of porters could change the tanks every 30 to 50 miles, as the weather might require. In case of collision, the wrought-metal tanks would be unlikely to burst, and there would be no setting fire to the *débris*.

Baker's system of warming cars by water in pipes is already used in the best drawing room and sleeping cars, both of East and West. The heat is pleasant and temperate, and it is applied where it is wanted—at the bottom of the car—at the feet of the passengers. Of the apparatus, the "Chicago Railway Review" says: The principle is very simple—that of the circulation of hot water. From the water-enclosed furnace, placed at one end or suspended underneath the car, the hot water—charged with 33 per cent. of salt, to at once prevent freezing and increase its capacity for retaining heat—flows out through the pipes distributed along the floor of the car, returning automatically to the furnace as it becomes cool. The apparatus would be little liable to accident from fire in any case; and, to make assurance doubly sure, the water surrounds the fire, so that in case of accident, it would put it out. The economy of fuel (three-fourths) and labor is extraordinary—the furnace being filled, for instance, at Chicago, locked up, and requiring no further attention till Buffalo is reached. In another important respect, the economy is notable, as compared with the stove-heated car. Instead of two stoves, one furnace is used. As this (placed in one corner) gives out no heat directly, there is a practical saving of 6 seats in each car—a common stove not only occupying the place of a single seat, but rendering the two adjoining seats uncomfortable.

A new method of heating cars, tried on the Connecticut River Railroad, is thus described:

A bonnet is placed on the top of the car at each end, to catch the wind while the car is in motion; the air rushes down a pipe into a water box, where it is thoroughly washed, and thence into a hot air-chamber surrounding a stove, whence it is forced in a pure state into pipes that run near th efloor, the whole length of the car, on each side and under the seats. At proper intervals these pipes are perforated with small holes, through which the heated air escapes. The warmth is distributed equally throughout the entire length of the car, and coming low down towards the floor will enable passengers to always keep their feet comfortably warm.

Another much needed railway accommodation would be the timely indication of stations. On many roads stations are not habitually called out by the brakemen; on most roads they are indistinctly called; on all roads they are not called till the train stops, thus giving too little time for ladies and children to prepare to alight. And as the attendants on American trains are few, and very busy at stations, passengers must, in the majority of cases, know the station, or take pains to get out and ask, or be carried on. A revolving sign at each end of the car, legible to all, and to be set by the brakeman just before stopping at stations, would be simple and effective. Such an apparatus has been introduced on the Ogdensburg and Lake Champlain Railway. It consists externally of a box surmounted by a bell, and having a glass plate in front, under which the name of a station appears in letters of about 3 inches in length. When the train arrives at the station named on the indicator, the bell on the top of the box rings, and presently the name of the next station on the line appears under the glass plate.

Speaking of attendance, the following railway order is commended to railway managers without many exceptions. It is posted in the station houses on the Rutland Railroad, in Vermont:

"Baggage men at the depots, and men on the trains—freight as well as passenger—are expected, and are employed by this Company, not only to do their work well, but pleasantly—to give every facility to travellers, by information and by acts. Any departure from civility of conduct, and that courtesy due the patrons of the road, will render them unfit for its service, and they will be dismissed accordingly. Travellers may be unreasonable, but this will be considered no excuse for any employé to be so in return."

It is hardly necessary to add, that the Railway Dinners and Lunches of America, as well as of England, may be improved.

The "New York World" says that Mr. Charles Dickens has again set on foot in England a much-needed reform. "Mugby Junction" has done more for the railroad commissariat than all the sanitary regulations, newspaper agitation, and individual growling put together. John Bull, stung in his stomach by satire, has set to work in good earnest to reform the refreshment saloons on the great railway lines, and it now seems likely that the very simple and excellent plan of supplying "locomotive luncheons" at one station, neatly and compactly arranged in baskets, which are left at the next station, is to become general. But it is in America, above all other places, that an economical and expeditious system of victualling passengers, should be devised, for here the routes are longest and the stations isolated.

IMPROVED TURBINE.—Mr. Paul R. Hodge, of London, has designed an arrangement for counterbalancing the pressure of the water on the wheel, also the weight of the shaft, etc., also for regulating the velocity of the wheel by the governor by the assistance of a working column, instead of blocking off the water from the guide curves or delivery buckets. These, and his improved method of obtaining the guide and delivery curves, are illustrated in "Engineering" of October 30 last.

There are two *improved Fourneyron wheels* on one shaft, one working above the casing and the other below; inside the casing there are the two sets of guide curves answering to each wheel. The pressure of water due to the head or column is counterbalanced by the introduction of the second wheel above, thereby effectually taking the pressure off the step of the shaft.

The manner of regulating the wheel by the governor is as follows: The governor operates on a vertical rod, to which is attached the balanced sluice or puppet valves for the regulating of the quantity of water in its passage from the reservoir to the working column at some distance above the wheel, so that if, when the wheel is working at its maximum of effect, a certain portion of the load is suddenly thrown off, then the sluice valves close and the working column is reduced to an extent corresponding to the reduction of the load on the machine. When an increased load is again thrown on, the governor reopens the valves and admits water corresponding to the increased load. By this arrangement the objectionable methods of blocking off the water from the wheel, either by the guide curves or delivery buckets, is done away with, it being a well-ascertained fact, that, when 10 per cent. of water is stopped off by the latter method, there is a loss of at least 30 per cent. of effect.

IRON AND STEEL INSTITUTE.

The ironmasters and steel manufacturers of Great Britain have resolved upon forming an "Iron and Steel Institute," for the discussion of questions of practical and scientific interest. The general principles of the proposed Institute will be similar to those adopted by the Civil and Mechanical Engineers, and other kindred societies, all questions bearing on trade regulations and wages being rigidly excluded.

From the number and position of the gentlemen who have taken an interest in the project, no doubt need now be entertained, says the "Mining Journal," of its being carried to a successful issue. Each of the ironmaking districts is well represented, as will be seen from the subjoined list of appointments to the provisional committee which have been made :

North of England.—Messrs. Edward Williams, Isaac Lowthian Bell, David Dale, James Morrison, B. Samuelson, M. P., W. R. Innes Hopkins, Charles Bagnall, M. P., John Jones.

West Coast.—Messrs. Joseph T. Smith, W. Fletcher, John Lancaster, J. Paterson, James Smith.

South Staffordshire.—Messrs. G. J. Barker, Walter Williams, William Matthews, John Hartley, William M. Sparrow, Frederick Smith, Saunders, Sampson Lloyd.

North Staffordshire.—Messrs. W. S. Roden, Robert Heath, J. Udall, J. Ramsbottom.

South Wales and Monmouth.—Messrs. W. Menelaus, A. Brogden, R. Fothergill, Budd, Abraham Darby, Struve.

Shropshire.—Mr. Thomas Horton.

Sheffield (Steel).—Messrs. Henry Bessemer, Edward Vickers, George Wilson, Mark Firth.

West Riding.—Messrs. F. Kitson, Jefferies, John Butler.

Derbyshire.—Messrs. J. G. N. Alleyne, William Fowler.

Scotland.—Messrs. Walter Neilson, Whitelaw, R. Cassels, Robert Hannay, Neil Robson.

It is gratifying to find that there appears to be every disposition on the part of the provisional committee to make the institution that which it professes to be —a national association; and with this view it has been decided that the makers of iron and steel in the several districts shall be asked to become members, and that the headquarters of the proposed institute shall be London, periodical meetings being held in the various ironmaking districts. By this means will be removed all cause for little jealousies which might arise from a particular producing district possessing the advantages of being the seat of the society's headquarters. Such associations as the Iron and Steel Institute are well calculated to promote the material progress of the branch of industry with which they may be connected, and it is to be hoped no time will be lost in bringing the project into working order.

THE CHENOT STEEL PROCESS.

Removing and treating the pure iron from a blast furnace before it becomes carburized, has been the subject of some experiments, many schemes, and great expectations. The scheme of M. Chenot is well described by M. Laudrin in his treatise on steel, but its practical and commercial prospects are not hopeful.

In the ordinary blast furnace where pig iron is produced, there are two distinct operations at two different heights of the stack. The iron ore, which is a compound of iron, oxygen, and earthy matter, is reduced in the upper parts of the furnace after somewhat complex reactions. At a certain height the ore comes in contact with carbonic oxide, which unites with its oxygen, and escapes at the mouth as carbonic acid. The earths which accompany it become separated, and fall to the lower part of the furnace, where they are transformed into slags or cinders. The iron is reduced, and remains pure. The height where these reactions occur is termed the zone of reduction; the heat is intense. At this point let us see what happens. The carbonic acid escapes at the top of the furnace, the iron and slag remain, and, on account of their specific gravity, fall to the lower part of the furnace, where the temperature is greater, and there undergo new reactions. Every one at this stage of the operation will think it would be more advantageous to extract the perfectly pure iron instead of allowing it to fall among the incandescent coals, where it is transformed into carbide or pig iron. Such was the idea of

M. Adrien Chenot, who thought of stopping the operation just when the ore had been converted into pure iron. An intense heat reigns in the greater part of the furnace 16 feet above the zone of reduction, and 33 feet underneath. Why should such a heat be kept 10 metres under the point where the pure iron is obtained? We readily understand that, when pig iron is wanted, such a heat is maintained underneath in order that the iron shall be converted into pig metal in a carburizing atmosphere. But, when ductile iron is wanted, we think it is useless and costly to keep up the combustion of the fuel when the product sought for is already obtained. Following these principles, M. Chenot, instead of heating the furnace underneath the boshes, that is, the lower part, has directed the highest temperature to be applied at the zone of reduction. The combustion ends there. The pure iron thus produced descends gradually into cold boshes, where it cannot undergo any new reaction, and where it is found in spongy masses mixed with the earths. The only operation which remains is the separation of the iron from the earths. This is effected by powerful magnets, which, being presented to the cold and pulverized residue, separate the iron in a state of perfect purity. This powder of pure iron being submitted afterwards to an enormous pressure which reaches above 700 atmospheres, has its atoms so strongly united that it acquires the density of iron itself, and may be drawn into bars, and undergo all the operations of a forge.

The compressed sponge is used by M. Chenot for cementing iron, and conversion into steel. It has been found by experiment to absorb its own volume of liquid; therefore it is sufficient to dip it into an oleaginous liquid, as coal tar, in order to produce a true carbide, not by combination, but by mixture. The metallic mass thus impregnated is put into pots and cast in the usual way.

EFFECT ON CLIMATE AND LAND, OF OPENING THE SUEZ CANAL.—In his address before the British Association, Mr. Bidder called upon it to get information as to the effect of filling a lake (now dry) of 150 square miles extent, and thus adding 2,500 cubic feet per minute to the evaporation, equal to a rainfall of 365 inches per annum.

RAILWAY BRAKES.

No sooner was the problem of setting trains in motion by steam satisfactorily solved, than a more difficult one, that of arresting their motion, arose in its place. It is not too much to assert that, in spite of the innumerable patents taken out, inventions experimented upon, and trials undergone, the question of obtaining a perfectly satisfactory brake action is yet an undecided one. Probably, the real reason why the difficulty has not been overcome, is that too much has been sought for, and too rigorous a solution of the problem attempted. Inventors, as a rule, have striven, with inexhaustible patience and assiduity, to design a brake that will stop a train almost instantaneously, and those who have effected the change from rapid motion to a state of complete repose in the shortest time, have considered that they have approached nearest to the vanquishing of the obstacle. But in fact they were very far from attaining the desired result. The great object of a brake is not to suddenly and totally arrest the progress of the train, but to gradually reduce it to a state of rest. It is not expected to act only on rare and special emergencies, but to be of continual use during the whole journey. In a word, it is for general, and not special employment. In order to obtain a sudden arrest of motion, all the earlier, and most of the recent, descriptions of brake were made to lock the wheels immediately upon their application. Independently of the great impactive force suddenly brought into play, and the violent torsion thrown upon the axles by this arrangement, it is radically unsound in principle, and does not effect the result desired. If the skids (brake blocks) press so tightly upon the wheels as to lock them, the train is not brought to rest so soon as if they only had bite sufficient to prevent them from revolving. To determine theoretically the exact velocity at which a body will cease to roll and commence to slide, is a very nice mathematical problem, but practically the limits may be ascertained experimentally with sufficient accuracy for all working purposes. At the late Exposition, the improvements in the details of brake gear were mostly confined to effecting the instantaneous application of the skids to the wheels. These comprised the use of levers, screws, springs, balance weights, and other contrivances, including automatic and electrical agencies.—*Mechanics' Magazine.*

We think the requirements of a brake are correctly stated above, and we would call the attention of English railway managers to the American Creamer brake, which we think fulfils these requirements in a marked and useful degree, if not absolutely.

THE GAS MANUFACTURE.

Compiled from a paper by Mr. Gore before the Society of Engineers, and from the address of Mr. Barlow before the British Association of Gas Managers.

Among the varied applications of scientific discovery to the purposes of daily life during the last century, few, if any, have attained greater importance than that which relates to the manufacture and application of coal gas. Scarcely a city, town, or village, of considerable size, in this country, or on the Continent, or even in the United States of America, remains unsupplied with this almost indispensable agent, in our industrial and social existence. Its use is rapidly extending in more remote regions, for strange as it may appear, there are many peoples and communities who, though persistently resisting useful applications of practical science as dangerous innovations, are yet eager to avail themselves of the use of gas as a source of artificial light and heat. Even religious prejudices of the most obstinate character have succumbed to this desire, and we now behold the Christian Church, the Mosque of the Mahometan, the Hindoo, Buddhist, and even the Chinese Temple, each illuminated by this simple yet beautiful light.

Composition of Coal Gas.—In the absence of any other well-supported theory, it is the generally received opinion that the light afforded by this gas is due to the amount of solid carbon incandescent in the flame at the moment of combustion. The two most important gaseous compounds of hydrogen and carbon, are marsh gas, or light carburetted hydrogen, and the other olefiant gas. The composition of the first is represented by the symbols $C\ H_2$, and consists by weight of 75.4 of carbon, and 24.6 of hydrogen. The composition of the second is represented by the symbols $C_2\ H_2$, and consists of 86 parts of carbon and 12 of hydrogen. The permanently gaseous constituents of all coal gas consist essentially of combinations of these two fluids or compound gases; but experiment shows that it is not a chemical union that is formed between them, but simply a mechanical mixture that takes place. Thus some coal gas of low illuminating power consists principally of marsh gas, with a very slight proportion of olefiant gas; other gas, of high illuminating power, contains an excess of olefiant gas. But the value of gas as a source of light is not due entirely to its gaseous constituents, for it almost always contains a certain quantity of vapors, more or less rich in carbon, and therefore extremely valuable as light-giving agents.

Quality of Gas.—What is technically called a poor gas coal always yields gas of the most permanent character, and is the most uniform in its amount of illuminating power, owing to the small amount of hydrocarbon vapors, and hence the small mechanical mixture. With a coal rich in the constituents of olefiant gas, the illuminating power, though actually much greater, is still liable to more variation than is the case with the poorer gas; but the greatest instability is experienced when a mixture of poor and rich coal is used. The gases generated from this mixture form but a feeble combination, the one with the other. The hydrocarbon vapors are merely held in suspension, and do not enter into union with either of the gases; the slightest obstruction, or the lowering of the temperature, soon destroys this slender connection, and the result is the loss of a very considerable portion of the illuminating elements of such gas. It is strange yet true that this last process of manufacturing by mixed material is the one very generally adopted.

Quantity *vs.* Quality.—In the earlier years of gas lighting illuminating power was not regarded of any great importance. And when opposition was raised it was almost always on the ground of price. This led to the establishment of the Great Central Company for the supply of the City of London, upon the fundamental principles of a low price and a low standard of illuminating power. To carry these proposals into practice involved some important modifications and changes in the machinery and apparatus. The principle laid down in the case of the Great Central Company has been more or less applied throughout the country, and the result has been that the constructive details of gas works have been carried out almost exclusively with a view to obtain the largest possible *quantity* of gas from the materials used for its production. Furnaces affording the greatest heat, retorts exposing the largest carbonizing surface, condensers and scrubbers making the strongest ammoniacal liquor, purifiers of large capacity and surface for the oxide system of purification, monster gas-holders, and last, though not least, street mains of the dimensions of small tunnels; these, and perhaps some other matters, are the concomitants of cheap gas, as inaugurated at the period above referred to.

Subsequent events, however, have shown that at least one of the parties to the arrangement (the gas consumers) have become dissatisfied with their bargain. The Legislature has so far interfered as to raise considerably the standard of illuminating power, and the question presents itself whether, in meeting this change, it may not be requisite to modify the present mode of constructing gas works, especially where mixed coals are used.

Retorts and Dip-pipes.—In large works, and with clay retorts, the system of through setting, with double mouth-pieces, is unquestionably the most economical, both as regards fuel and durability. But this arrangement is open to grave objections. If the retorts are used for the generation of gas of high illuminating power, the increased surface over which the gas passes after it is eliminated from the coal exposes it to the chance of decomposition, and the consequent deposition of its carbon. In through retorts this deposition is due mainly to two causes; in the first place, in charging the retort, the centre scarcely ever receives its due portion of coal, and as this part is always the hottest, it follows that the gas generated from the thinner stratum of coal is exposed to intense heat, and a portion of it is speedily decomposed. Another cause of this deposit is the want of uniformity in the pressure in the two hydraulic mains; a slight resistance in one main or the other causes the gas to take the course offering least obstruction, and as the particles of gas thus pass over a larger amount of heated surface, they are exposed to the greater risk of decomposition. Several expedients have been suggested to remedy this evil; one is to use a valve to each ascension pipe, so as to dispense with the dip-pipe when the retort is working; another is to have only one hydraulic main, placed over the centre of the ovens, and both mouth-pieces connected to it by a single dip-pipe.

Some farther modifications made in the form and arrangement of the dip-pipe tend to remove the inconvenience that arises from the necessity of having the dip-pipe sealed in the hydraulic main. An American inventor has suggested an alteration in the old form of hydraulic main by casting the dip on its side. This method of forming the dip-pipe presents some advantages in clearing out, and it avoids the inconvenience attending the collection of pitch round the mouths of the pipes. A more important arrangement of the dip-pipe, having for its object the removal of the pressure in the retorts occasioned by the seal in the hydraulic main, has been contrived by Messrs. Cockey & Sons. This arrangement is called a "telescopic" dip-pipe, that portion of it which enters the tar in the hydraulic main being made to slide up, like the tube of a telescope, as soon as the retort is charged; the action taking place by means of a lever to which a handle is attached. Before loosening the lid of the retort the telescope part of the pipe is lowered again into the tar to prevent the gas from passing back into the retort.

Machines for Drawing and Charging Retorts.—Of the mechanical appliances for the charging of retorts, by which a large system of retorts set in one oven may be charged at once, by a number of scoops operating at the same instant, Mr. Barlow says: The plan has been practically tried at the Alliance Gas Works in Dublin, and I am able to speak of it very favorably. A new retort-house has been erected, capable of carbonizing 300 tons of coal in a day, and containing 270 double retorts, or 540 mouth-pieces, the charging and discharging of which is performed by two machines, and hitherto with complete success. Best & Holden's "steam stoker," as the machine has been termed, appears to be destined to make a revolution in the retort-house arrangements of all large gas works. The patentees have contracted for the charging and discharging of the retorts at the rate of 9d. per ton, including royalty, the cost under the old system having been 1s. 7d.

The Condenser.—By the term condenser, we usually understand the apparatus acting as a means of refrigeration, but this is only true in reference to its use where the gas is of poor quality and of low specific gravity. In treating gases which are to possess high illuminating power, it is not desirable to reduce their temperature below 60 degrees. Under these circumstances, therefore, we must look upon the condenser as a seperator, and not simply as a refrigerator. The two forms of condensers most generally in use are the tubular, or series of pipes, and the annular. Whichever of these forms is adopted, a large extent of surface is indispensable, in order that the separation of the mechanical and non-chemical impurities contained in the crude gas may be gradual. The existence of naphthaline may in many cases no doubt be traced, first, to the high temperature at which the gas is generated, and again to the too sudden reduction of the temperature by rapid and excessive refrigeration. It is a strange anomaly that so much care and labor should be applied to remove so many of the light-giving constituents from the gas, and then to give back these elements by the use of costly, and in some cases dangerous appliances, in naphthalizers, carburetters, and other high-sounding and wonderful specifics.

Washing Gas.—After leaving the condenser the gas is subjected to washing, either by means of the old-fashioned wash-vessel, or the more modern "scrubber;" the object in either case being to purify the gas from any remaining particles of tar, heavy oils, and ammonia. Many very conflicting statements have been made in reference to the effect of water in removing some of the light-giving constituents from coal gas. Several chemists, who have the reputation of being oracles in these matters, have asserted that water exerts but a small influence in diminishing the illuminating power of coal gas. Some engineers, who certainly have an equal claim to consideration from their great practical experience, say, on the contrary, that water produces a very injurious effect. Mr. Gore here gives, at length, certain experiments which seem to prove the latter proposition, and says that after a series of trials, a system was adopted of allowing the water to flow through the scrubber for ten minutes, at intervals of two hours; the gas was sufficiently freed from tarry matter, and the illuminating power of 19 candles was always maintained, the average being 21 candles at the works.

Lime *vs.* Oxide of Iron.—In removing from gas the chemical impurities, lime is unquestionably the most appropriate agent, and, in all situations where it is possible to employ it, it should be used to the exclusion of all other substances. Considerations of economy, and certain sanitary regulations, have induced chemists and engineers to turn their attention to some of the metallic oxides as substances adapted for the purposes of gas purification, and now by common consent certain oxides of iron are used as a substitute for lime in most of our important gas works. The action of this material is to remove the sulphuretted hydrogen, by the union of the sulphur with the iron, forming the black sulphuret or sulphide of iron. When the material is fully saturated, it is removed from the purifier, and on exposure to the atmosphere undergoes a series of chemical changes, which result in the precipitation of the sulphur and the re-oxidation of the iron, which again becomes fitted to act as a purifying agent; in fact, the process of revivication may be carried on for months before the purifying power of the material is entirely exhausted. In constructing purifiers for the oxide of iron process, a much larger superficial area is necessary than when hydrate of lime is employed. It is very questionable, the author ventures to think, whether the practice of increasing the thickness of the layers of the oxide is in all respects good, especially when the material is partially spent.

Adulterations.—A very objectionable system is now pursued in gas manufacture of disregarding the existence of carbonic acid in gas. The reason assigned for this practice is that the quantity is so small that its interference with the illuminating power of the gas is easily compensated for by adding a little more Cannel in the process of manufacture. Another economic suggestion has been made, namely, the revivication of the oxide in the purifier itself, by allowing a portion of atmospheric air to be driven through the material along with the gas, thus causing a constant decomposition of the sulphuret as fast as it is formed; the injury resulting to the illuminating power of gas is to be remedied by that panacea for most, if not for all, of the ills attendant on gas lighting—"a little more Cannel"—but any admixture of atmospheric air should certainly be avoided, first, because it is a dishonest adulteration of the gas, and, secondly, because it is unsafe, and may lead to the most disastrous consequences.

Gas-Holders.—It must be admitted that the larger the gas-holder the cheaper its cost at per 1,000 feet of its contents; but it is a question for serious consideration whether, as a matter of safety, these enormous depositories are not open to grave objections. So long as the quantity produced in the course of manufacture was the essential object of our manipulations, the effect on the quality of gas by its storage was only of secondary importance; but if a higher standard of illuminating power is to be imposed, the advantages of these enormous gas-holders may not prove so obvious. The storing of gas (especially such as contains any considerable amount of hydrocarbon vapors) is sure to result in an appreciable diminution of its illuminating effect.

Situation of Works.—In selecting a site for works, the following are among the most essential desiderata: Sufficiency of area, a low level, a good supply of water, good drainage, and easy access. In the earlier times of gas engineering it was thought desirable that the supply should be as near as possible to the centre of the consumption, but modern practice removes our gas works to remote distances, and some enthusiastic persons have even suggested the removal of the manufactories to the centres of our coal districts. Wild as this proposal seems, it might possibly be realized, if gas and not light was the product to be supplied; but if the public demand gas light, and not light gas, then the proximity of the works to the locality of the consumption must be a vital element in the economy of gas manufacture. The longer the distance through which the gas has to travel before reaching the burner of the consumer, the greater will be the loss of illuminating power; hence it follows that a company supplying gas from works three or four miles from the district or place where the gas is to be consumed, will have to use a much larger proportion of Cannel, or other light-producing material, to produce and supply gas of equal quality with a company only a mile from its consumers. It is very questionable if the advantages said to be gained in a sanitary point of view, or the greater economy effected in the delivery of raw materials, and the distribution of residual products, as coke, tar, liquor, etc., will at all compensate for the increased outlay in mains and the attendant loss of illuminating power.

New Methods for Gas-Making.—The pressure which the Legislature has recently put on gas companies to raise the standard of illuminating power considerably above that obtainable from common coal, has compelled most of them to use a certain proportion of Cannel coal at a heavy cost and with a diminution in the value of the coke. The advance in the price of Cannel consequent on the increased consumption has stimulated inquiry to find a substitute for it, and this seems to have been accomplished by Mr. McKenzie, whose process of mixing small coal with crude shale oil has been successfully adopted on a large scale at the Alliance Gas Works in Dublin. The small coal is well mixed with the oil in the proportions varying from 10 to 30 gallons to 1 ton of coals. This is effected by means of a mixing or grinding mill. The compound material is then distilled in ordinary gas-retorts of clay or iron at a strong heat approaching a white heat. From a mixture of Llantwit small coal, costing 12s. 6d. per ton, with 5 per cent. of Broxbourne shale oil, costing £5 per ton, the produce of the distillation of one ton of the mixture was—

9,750 cubic feet of gas of 21.5 candles illuminating power.

37 bushels of good hard saleable coke.

2 bushels of breeze.

11 gallons of tar.

15 gallons of ammoniacal liquor of 5° twaddle.

The cost of this mixture, including royalty, was about 17s. per ton against 24s. for Wigan cannel, over which it has the advantage of at least 5s. per ton in the value of the coke.

Two other new sources of supply of materials for producing gas of high illuminating power have been proposed—viz., New Brunswick albertite and Trinidad bitumen. From the results of experiments on the former made by Mr. Evans, at the Horseferry Road works of Chartered Company, it appears that the yield per ton is from 9,166 to 10,200 cubic feet of gas, varying in illuminating power from 23.66 to 35.42 candles, from which quantity, however, 10 per cent. must be deducted in practical operations on a working scale, and the material is offered for sale in London at 37s. 6d. per ton. Trinidad bitumen does not present quite the same advantages. When mixed with 80 per cent. of Newcastle coal the yield per ton, according to the joint experiments of Dr. Letheby and Mr. Keats, was 10,600 cubic feet of 17.6-candle gas, and it could be sold in London at from 45s. to 50s. per ton. There is, however, the serious drawback to the use of Trinidad bitumen that it contains a large amount of sulphur and water.

The "Mechanics' Magazine," refers to a number of successful experiments in this direction, but says we are making no *practical* progress; the companies are not taking up the new process, and the public are reaping no benefits. According to Mr. H. P. Stephenson, gas engineer, a mixture of 20 per cent. of bitumen with 80 per cent. of Lord Belhaven's main coal, distilled at a red heat, produced 9,072 feet of 14-candle gas. Thus a coal which is unfit for the production of gas when carbonized alone is rendered useful. Some experiments carried out at the Woolwich Arsenal Gas Works, with mixtures of coal and bitumen, showed that a mixture of 25 parts of bitumen and 75 of coal yielded at the rate of 9,856 feet to the ton of 20-candle gas. It was estimated that the cost of such gas to the consumer, the materials being furnished respectively at 32s. and 16s. per ton, would not exceed 3s. 7d. per 1,000 feet of gas sold. A long series of trials on a manufacturing scale, made by the Gas Committee of the City Corporation of London, and conducted by Professor Frankland, Mr Hughes, C. E., and Mr. Stephenson, C. E., showed conclusively that when the raw materials were supplied at the prices we have named, 20-candle gas could be sold at a large profit at 3s. 7d. per 1,000 feet. Professor Odling has also made a series of laboratory experiments upon the use of bitumen for gas purposes, with highly favorable results. Other eminent men have also made trials which resulted most favorably. Where is the hitch? Are the gas companies enjoying too comfortable a monopoly to risk a change?

Gas as a Motive Power.—The successful application of the explosive force of gas as a motive power opens an extensive field for the demand for gas for day consumption in manufacturing towns; and it is a matter of great surprise that gas companies have not made exertions to promote the use of the gas engines. Improvements have been made on the original form of the Lenoir engines by Messrs. Kinder and Kinsey, by which its power and efficiency have been considerably increased.

LOCOMOTIVE Cotton Press.—Mr. C. G. Wilson, of London, has mounted a hydraulic cotton press upon a traction engine for service in India. The engine will be conveyed on a railway truck to the various stations on the line of railway in the cotton districts, where it will remain for sufficient time to press into bales the cotton stored there; when required, the engine will proceed by its own traction power to the depots in the great fields.

The engine can also furnish power for other presses, mounted on a carriage without steam power, and may also be employed to drive cotton gins, etc., by means of belts.

After describing the press in detail, the "Mechanics' Magazine" (October 16, 1868), says: Unpressed cotton is so liable to be destroyed by fire, that one Indian railway company alone had claims amounting to £30,000 made upon it in a single year. Compressed cotton will not burn; therefore there can be no question that Mr. Wilson has, by the invention of this press, done much not only to facilitate the transport of cotton, but to cheapen that commodity in this country.

BOAT Construction.—A recent English patent specifies boats built of staves like a cask, with a central opening cut out and surrounded by a combing.

THE NITRATE OF SODA STEEL PROCESS.

HEATON'S PROCESS AND PLANT.—BESSEMER'S APPARATUS.

The Heaton process of decarburizing cast-iron, says "The Engineer," has for some time been employed on a manufacturing scale with complete success at the Langley Mill Works, Nottingham, and is competent to make remarkably fine steel and "steel iron," from the very worst and most sulphur and phosphorus-charged "makes" of iron in Great Britain, and in a word, to make excellent marketable steel from any "make" of pig iron that may be put into the Heaton converter.

This process consists in the application to the molten crude iron, of a far more powerful and searching agent than heated air—namely, the *nascent oxygen* developed at the moment of contact between the molten cast-iron and such classes of salts, nitrates, etc., as yield oxygen under those conditions. The mere idea of decarburizing crude iron by the use of nitrates, is by no means novel. Notices will be found in many old chemical works of the reactions produced by nitre upon red-hot iron.

Nitrate of soda is the form of nitre employed by Mr. Heaton. It is not decomposed in presence of fluid cast-iron with the same intense energy that nitre is, but still would prove an agent for the burning out of the silicon, carbon, sulphur, phosphorus, etc., more or less unmanageable, were it not for the extremely simple but beautifully effective apparatus invented for its application, and which constitutes, in fact, the essence of Mr. Heaton's patents. The following is an outline of the process and its results :

Pig or other cast-iron, whatever be its quality, is melted in a common iron foundry cupola with coke fuel. The liquid iron in known mass—usually from a ton at a time to perhaps hereafter as much as five tons—is tapped out into an ordinary crane ladle, and the latter is swung round to the side of the converter. The converter consists of a tall cylinder of boiler plate, open at bottom, which is supported at a certain height above the floor beneath it. This cylinder is lined with fire-brick, and above its upper part rises a cone and a funnel of plate iron, freely open at top. To the bottom of the cylinder any number in succession of short nearly cylindrical pots lined with brick and fire-clay, and in form very like crane ladles, are adjustable by simple means. Into the bottom of one of these pots a known weight of crude nitrate of soda of commerce is put ; the surface of the gross powder is levelled and covered by a pretty thick circular plate of cast-iron, perforated with many holes, which lies by its own weight upon the top of the nitrate. One of these pots thus prepared having been adjusted to the bottom of the cylinder, the converter is now ready for use. At one side of the cylinder described, is a sort of hopper funnel, covered by a loosely hinged flap of boiler plate. This plate is raised, and the ladle full of liquid cast-iron is at once poured into the converter, and so descends right down upon the top of the cold cast-iron perforated plate. The plate does not float up nor become displaced, nor does any action become apparent for some minutes, while the plate is rapidly acquiring heat from the fluid iron above it, and the nitrate getting heated by contact with it. What follows we may describe in Professor Miller's own words, from his personal observation and report :—"In about two minutes a reaction commenced; at first a moderate quantity of brown nitrous fumes escaped ; these were followed by copious blackish, then gray, then whitish fumes, produced by the escape of steam, carrying with it, in suspension, a portion of the flux. After the lapse of five or six minutes deflagration occurred, attended with a roaring noise and a burst of a brilliant yellow flame from the top of the chimney. This lasted for about a minute and a half, and then subsided as rapidly as it commenced. When all had become tranquil the converter was detached from the chimney, and its contents were emptied upon the iron pavement of the foundry. These consisted of 'crude steel' and of slag. The 'crude steel' was in a pasty state, and the slag fluid; the cast-iron perforated plate had become melted up and incorporated with the charge of molten metal."

The first product of the Heaton process, which he denominates "crude steel," is in reality malleable iron of the very purest and finest quality. The broken up lumps of this material, direct from the converter, only require, after they have been "patted" or squeezed under the "shingling hammer" to condense their spongy texture, to be heated again in a common "balling furnace," and rolled at once into bars, or forged or rolled into any desirable form. In this state the material is very unhappily called by the inventor "steel iron." It has but little pretensions to be called so; it scarcely perceptibly hardens in water. What it really consists of is crystallo-fibrous wrought-iron, almost absolutely sulphur and phosphorus free, of great strength and toughness, and for every structural purpose equal to the renowned wrought-iron produced at Lowmoor and Bowling works. It welds perfectly; it is tough both hot and cold, neither red-short nor cold-short, and forges beautifully at both the test temperatures for iron—a low red, and a clear yellow heat.

The "steel iron" is itself of course a valuable material ready for market. From this material it is, that Mr. Heaton makes his cast-steel, that is, before it has been subjected to any rolling, while in the state merely of "crude steel," patted into cakes by the shingling hammer. These cakes are broken up, put into ordinary clay melting pots of the usual size, holding about 60 pounds each. To each 100 pounds of the material, about 2½ pounds or 3 pounds of spiegeleisen, or its equivalent of oxide of manganese and a little charcoal, are added, and the whole is fused and cast into the ordinary ingots of iron. It is now excellent cast-steel, and when the ingots have been tilted in the usual manner, cast-steel bars are produced fit for any uses to which steel is at present applied. Such is the Heaton process; its simplicity and directness need no comment to those acquainted with ordinary iron and steel making.

The following analyses of the iron treated, and the resulting products are from Dr. Miller's official report:

	Cupola. Pig (4).	Crude. Steel (7).	Bar. Steel (8).
Carbon	2·830	1·800	0·993
Silicon, with a little titanium	2·950	0·266	0·149
Sulphur	0·113	0·018	traces.
Phosphorus	1·455	0·298	0·292
Arsenic	0·041	0·039	0·024
Manganese	0·318	0·090	0·088
Calcium	——	0·319	0·310
Sodium	——	0·144	traces.
Iron (by difference)	92·293	97·026	98·144
	100·000	100·000	100·000

The report also says: The chemical principle appears to be good, and the mode of attaining the result is both simple and rapid. The nitric acid of the nitrate in this operation imparts oxygen to the impurities always present in cast-iron, converting them into compounds which combine with the sodium, and these are removed with the sodium in the slag. This action of the sodium is one of the peculiar features of Heaton's process, and gives it an advantage over the oxidizing methods in common use.

Upon the appearance of the foregoing in "The Engineer," the London professional papers contained many comments by editors and correspondents, the gist of which are as follows. "The Engineer" says: Mr. Bessemer, in one of his patents, long ago claimed the use of any solid substance capable of evolving oxygen for the conversion of iron into steel; and if such a claim could be maintained, as we presume it might be, the nitrate process would be no more than a modification of Mr. Bessemer's better known system of compressed air jets. But if it be proved to have the distinctive power of removing phosphorus, it takes a still higher rank.

Professor Miller states that pig iron, containing 1.455 per cent. of phosphorus, loses all but 0.298, or say $\frac{3}{10}$ths per cent. in the nitrate converter. Yet of the 2.83 per cent. of carbon in the same pig iron, but 1.03 per cent. was removed, and 1.8 per cent. remained, and there remained also 0.266 per cent. of silicon, besides small quantities of sulphur, arsenic, calcium, sodium, etc.; so that the pure iron remaining was but 97.026 per cent., whereas in good steel it should be nearly, or quite, 99½. Every competent metallurgist will at once percieve that this so-called "crude steel" is very crude indeed—that it is, in fact, only comparable to half puddled iron, long before it has come to nature; and any one who has paid the least attention to the chemical composition of steel must be aware that samples containing 1.8 per cent. of carbon are wholly unfitted for any purpose to which steel is applicable.

Mr. Robert Mushet says: The Bessemer process converts melted cast-iron at once into steel, keeping that steel liquid until it is poured into ingot moulds forming ingots fit for drawing or rolling out into bars of cast-steel. The Heaton process takes melted cast-iron and treats it with nitrate of soda in a converter, and the result of this treatment is to deprive the cast-iron of much of its carbon, in consequence of which, as there is not, as in the Bessemer converter, any means of increasing the temperature, the iron assumes a pasty condition, and is emptied out on the floor in place of into ingot moulds. Scarcely so direct this as the Bessemer process. But now comes the cream of the joke. The pasty stuff turned out on the floor is, as Mr. Heaton properly terms it, "crude steel." (Mr. Mushet then goes on to show that it is very crude, as above explained—too much carbon and phosphorus.) Some of this pasty matter, which had been "patted" or squeezed into cakes, I found could not be forged at any temperature, far less would it weld; and when melted in crucibles, it proved considerably inferior to ordinary Bessemer scrap steel, for the manufacture of cast-steel. Dr. Miller also states that the maximum amount of slag from the converter did not exceed 23 per cent. of the weight of the metal charged. Where did it come from, if even 20 per cent.?

Mr. Mushet concludes: No one has ever doubted that nitrate of soda will eliminate, more or less, sulphur and phosphorus from cast iron, but as it does not generate a lasting and progressively increasing temperature, thereby rendering the purified metal fluid so that it can be cast into ingots, it follows that the Heaton process can never compete with the Bessemer process.

Mr. Ferd. Kohn says: The conclusions arrived at by Professor Miller are not in accordance with the theory originated, I believe, by Dr. Percy, and now adopted by the majority of metallurgists, viz., that the presence of alkaline or other basic matter during the process of decarburization has very little effect or influence upon the removal of phosphorus in the shape of phosphoric acid, but that the phosphorus is separated from the iron as phosphide of iron. This phosphide of iron is liquid at a temperature at which the malleable iron solidifies, and can therefore be mechanically separated from the iron by hammering or squeezing. Mr. Kohn then proceeds to show that Professor Miller has only accounted for 8 out of the 15 pounds of phosphorus that disappeared from the iron in the operation described. The 8 pounds were found in the slag. The remainder must have been squeezed out by the subsequent hammering and rolling, just as it would be in the treatment of puddle balls.

Another correspondent of "Engineering" says, that as some 3½ cwt. of nitrate of soda, at £10 per ton, are required for a ton of crude "coke" produced, he does not see the advantage in buying pig iron, say 30s. cheaper than Bessemer pigs, and then spending 38s. worth of nitrates for bringing out a material which is certainly not as pure as hematite pigs after all, and which you must scrape together from the floor of your forge in order to get it into anything like a workable state by a second process.

In a paper read by Mr. John Gjers before the Cleveland Institution of Engineers in April last, it is stated that several patents existed before either Mr. Heaton's or Mr. Hargreave's time, for the use of oxidizing salts, amongst which nitrates are named; and in the patent granted to Knowles, dated July 10, 1857, No. 1,921, nitrate of soda is specially claimed for refining iron, by pouring melted pig iron upon the salt in a ladle. This patent, as well as other patents for the use of nitrates, and almost every other oxidizing salt, applied both in separate vessels and in the puddling furnace, are now expired, and consequently public property. This paper also states, that as a result of analyses, this metal comes very far short of what was pretended, as nearly the whole of the phosphorus, the greater part of the carbon, and a considerable quantity of silicon is left in the metal, and very little in the slag, and that it is in every respect considerably inferior even to common refined plate.

An apparatus has recently been patented by Mr. Henry Bessemer for following out his early propositions of decarburizing iron by the use of substances capable of evolving oxygen, this apparatus being practically applicable for the use of nitrates, or chlorates of soda or potash and other salts, which evolve oxygen gas when heated.

One method of conducting this process is to place beneath the molten iron a perforated case capable of bearing a high heat, and containing the nitrate of soda or other solid matter. The heat of the molten iron causes the nitrate to liberate oxygen, which forces its way through the perforations in the case, and it issues into and amongst the particles of the molten iron, as when air is forced through the tuyeres in the ordinary way of conducting the Bessemer process. Mr. Bessemer's specification says : It is advantageous to use a converting vessel like that which is usually employed. I replace the tuyere box by a case of chamber lined with refractory material, and filled with the nitrate of soda or other material capable of evolving oxygen, and closed at the top with a perforated firetile. I make the case of such dimensions that the area of the surface of the nitrate is but small as compared with the area of the principal horizontal section of the metal in the converting vessel. In this way I both modify the intensity of the action and also prevent the rapid scoring action which would result from the passage of the gas between the metal and the sides of the vessel. Also in order to render the action more regular I fuse the nitrate and cast it into the case or chamber, and there allow it to solidify. The melted metal is then effectually prevented from acting on more than the upper surface of the cast block of nitrate ; or in some cases I mould the nitrate into blocks under heavy pressure before inserting it into the case or chamber, and the violence of the action of the nitrate may be reduced by mixing dry clay or other inert matter with it.

The invention also provides a means of forcing fluid nitrates into the converter, through the openings in a small central tuyere placed at the bottom of the converter instead of the ordinary tuyere box. A case containing the nitrate is attached to the converter and surrounded with an annular case. Into this annular case air or steam heated sufficiently to keep the nitrate fused, is forced by a pipe from the hollow trunnion in the ordinary manner. Below the chamber containing the nitrate, is a 4-way cock arranged to let air from the trunnion to the tuyere, for the purpose of heating the converter as usual, and also for the purpose of keeping the fluid iron out of the tuyere when the converter is turned up to blow, and the tuyere is thus brought beneath the fluid iron. By turning this 4-way cock when the converter is up, the air from the trunnion is shut off from the converter, and at the same instant let into the chamber containing the nitrate, while through the other passage in the 4-way cock, the bottom of the chamber containing the nitrate is connected with the pipe leading to the tuyere. Thus by the operation of turning the cock, air is shut off from the tuyere and nitrate forced into it, and thus into the molten iron in the converter, where the conversion proceeds in the ordinary manner.

A still later apparatus, patented by Mr. Bessemer, is illustrated in "Engineering," Nov. 13. The plan consists in forcing or injecting into molten crude iron streams or jets of fused fluid nitrate of soda or nitrate of potash; the streams or jets of fused or fluid matters are projected downwards at any desired angle from nozzles or tuyeres, the orifices of which are situated above the mean level or upper surface of the fluid iron to be operated upon, a portion of the said fused or fluid matters, as well as a portion of the cinder or oxides produced in the process, being again carried down into the molten metal as an induced current caused by the passage of the jets.

The process may be carried on in the ordinary converter, or in the hearth of a finery furnace. When employing such a furnace, Mr. Bessemer arranges a set of air tuyeres along one side for melting the pig metal and partially refining it; and on the other side of the hearth he employs a separate set of tuyeres or nozzles for the purpose of injecting the aforesaid fused or fluid matters into the molten iron. The process in this finery furnace may be discontinued while the metal is in the condition of highly refined cast-iron approaching to steel, or it may be continued until a more or less perfectly malleable metal is obtained suitable for melting in crucibles, or otherwise to form steel, or the metal may be allowed to granulate or assume a more or less solid condition, with or without manipulation with an iron bar or rabble, and be removed from the finery furnace in a condition to be formed into bars or blooms. The process may also be carried on in a reverberatory or puddling furnace heated by solid fuel, or by means of heated air and gas.

In carrying out the above process Mr. Bessemer prefers to melt the nitrate of soda, nitrate of potash, or other fusible matters in a jacketted iron vessel by means of highly-heated atmospheric air or superheated steam, and to use the pressure of such air or steam to act on the surface of the fluid matters, in order that they may thus be driven downward upon the fluid metal with such forceas to penetrate far into the molten mass, and put the latter into rapid motion, and thus in turn bring all parts under operation. This motion in cylindrical vessels is best attained by placing the jet pipes at a tangent to the circumference.

RAILWAY NOTES.

Railway Progress in the United States.—In 1865, the first 40 miles of the Union Pacific Railroad were laid; in 1866 there were constructed 265 miles; in 1867 a further length of 245 miles, and to November 1, in 1868, there had been constructed 330 miles, or, in 4 years, 880 miles. The total length of the road is 1,657 miles. The Central Pacific, notwithstanding the intervention of the Sierra Nevada, has progressed with equal rapidity; and the Union Pacific (E. D.) was, November 1, in operation from Kansas City to Sheridan, 405 miles. Railroad construction in the States east of the Mississippi and west of Pennsylvania has been during this period as follows:

———	Miles of Road.		
	1864.	1868.	Incr.
Iowa	800	1,680	830
Missouri	920	1,200	280
Minnesota	160	560	400
Wisconsin	1,050	1,200	150
Illinois	3,100	3,400	300
Michigan	870	1,260	390
Indiana	2,200	2,600	400
Ohio	3,200	3,340	140
Total	12,300	15,110	2,890

Thus in these 8 States in 4 years nearly 3,000 miles of new railroad have been laid and millions of dollars expended, not only on these, but also in improving previously existing lines. The total increase in cost has been nearly $200,000,000, or about $15 per head of the population.

Among the principal railroads in progress, or constructed in the four years referred to, the following are the most important:

In Iowa: the Iowa division of the Chicago and Northwestern, the Iowa division of the Chicago, Rock Island, and Pacific, the Burlington and Missouri River, the Sioux City and Pacific, and the St. Joseph and Council Bluffs. By the time that the Pacific Railroad is completed, the Rock Island and Burlington lines will have reached the Missouri.

In Missouri: the Pacific of Missouri, and the extensions of the North Missouri towards Iowa and the Missouri River. The Southern Pacific is also being extended southwest, and the St. Louis and Iron Mountain south, the latter to a connection with the Southern railroads at Columbus, Ky. The St. Joseph and Council Bluffs Railroad has also been completed to a connection with the Iowa Railroad of the same name, giving St. Louis an indirect route to Omaha. Several other roads are projected to connect with the Union Pacific Railroads.

In Minnesota: the Milwaukee and St. Paul, the Winona and St. Peter, and the Minnesota Valley. Considerable progress has also been made in the first division of the Pacific Railroad and its branch north to Watab has been opened through.

In Illinois: the St. Louis, Jacksonville, and Chicago, which gives another connection to the Illinois Central. The Rockford, Rock Island, and St. Louis is now in course of construction, chiefly as a mineral road, and designed to supply coal to railroads, etc. The St. Louis, Vandalia, and Terre Haute, and the Cairo, Mound City, and Vincennes are also in progress, with a view to their early completion.

In Michigan: the Jackson, Lansing, and Saginaw, and the Flint and Pere Marquette, are the principal new constructions. There is also being constructed a more direct line between Port Huron and Chicago, known as the Air-line. The Grand River Valley Railroad is approaching completion.

In Indiana: the Columbus and Indiana Central Railroad has completed a line from Union City to Logansport, and consolidated into itself the Chicago and Great Eastern, the Indiana Central and the Logansport and Burlington. There is also being built a line from Indianapolis to Vincennes to connect with the road to Mound City and Cairo; and several other lines are projected.

And in Ohio: several short lines, chiefly auxiliaries of existing lines. In this State several important consolidations have been effected.

Further east the principal developments have been rather improvements than new works. In New York the Erie is having a third rail laid to accommodate the narrow cars. The Hudson River has completed its second track, etc. The lines in progress from the Hudson have chiefly a northwestern direction, and will connect with the Central, the Midland being the most important. In a few years the Boston, Hartford, and Erie, will continue the Erie Railway to Boston. In the city of New York the depot and warehouse accommodation has been largely extended. In Pennsylvania, especially in the eastern portion, the extension of roads is being rapidly carried on, the objective points being Easton, on the Delaware, and New York city. In the southwest of the State the construction of the Pittsburg and Connellsville Railroad to a connection with the Baltimore and Ohio is being carried on actively. New Jersey has also made extensive improvements in its railroads and accommodations for an increasing traffic. The works at Hoboken, Jersey City, Communipaw, and Elizabethport are among the most extensive in the United States. In the Delaware peninsula railroad building is very active; and Maryland is connecting Baltimore more firmly with both East and West.—*Hunt's Merchants' Magazine.*

Irish Railways.—The total completed length of railways in Ireland is 1,908¼ miles of which there are 1,408 miles of single track, and 500¼ miles of double line. The length of railways in hand, and not yet finished, is 252 miles, and 339¼ are authorized, but not yet commenced. Of the first, the principal are the Great Southern and Western line, with a length of 165½ miles, and 253¼ miles of branches, connecting Cork with Dublin; the Great Northern and Western, 82¾ miles long, starting from Westport and ending with a junction at Athlone, with a short branch connected with the Great Southern and Western; the Midland Great Western, crossing the island from Galway to Dublin, with a length of 126½ miles of main lines and 120 miles of branches; and the Dublin, Wicklow, and Wexford Railway, with 98½ miles of main and branch lines.

On all these railways the bridge rail is the section principally employed, the mileage of flat-footed permanent way being 712¾; of double-headed rails 308; and bridge rails 1,750¼, which, together with 37 miles of various other sections, make a total of 2,408½ miles. The bridge section is, however, being abandoned, as is evidenced by the fact that only 6 of the different railway companies are adopting them for the permanent way renewals. The Great Southern and Western, who have hitherto employed rails weighing 80 and 90 pounds to the yard (the heaviest section in Ireland), are now replacing them with flat-footed rails. 26 other railways are following the example, while 6 companies are again employing the double-headed line.

Hoosic Tunnel Notes.—The work under the old contract has practically ceased, and it will not be renewed until a contract such as the last Legislature provided for is made and accepted by the Governor. The "Springfield Republican" says: We believe that the faith and hope in which the good people of the State have carried on the work, is fast breaking down. The tide is turning against the expenditure of any more of the people's money in that work. They say, "If it can be done, why will not the Fitchburg and the Vermont and Massachusetts railroads, which will most profit by it, and eventually will own it—why will not these corporations undertake the job and spend their own money in it? If they won't, we won't."

The condition of the work is as follows: On the east side the penetration reaches 1 mile through solid granite; the full-sized tunnel less than ½ a mile. The central shaft is sunk about 600 feet, and has 400 more to go. It is elliptical, 27 × 15 feet. On the west side the tunnel reaches 700 feet through quicksand and rotten stone, and is lined with brick. The west shaft is done, and the tunnel is driven from it 1,500 feet to the east, and 1,000 feet to the west. The entire length of the tunnel will be 4¾ miles, of which 3 are yet to be excavated.

Michigan Car Works.—The buildings of the Company at Detroit cover 4 acres. The specialty is freight cars. The number of hands is 150; the capital $100,000.

Railway Construction.—The following bits of high science are from a series of articles in a London technical paper. Speaking of sleepers: In America that kind of pine known as "Hemlock," or "Hemlock Spruce," has been found the best, although with such a choice of timber, white oak, chestnut, and all sorts of wood are used. Sleepers must always be straight, and of an uniform size, for otherwise the bearing or rather the running, would be commensurately imperfect, or "poor," as it is called. As to improved rails: Rails should be made of puddled iron, that is, iron into which atmospheric air has been introduced by stirring or "puddling" with a rod whilst in a soft state. We most of us know the mode of annealing, or rendering brittle iron wire soft, so that it will bend without breaking—namely, by heating and allowing it to cool—in other words, exposing it when hot to the air. This is a simple thing enough, and the principle upon which it is done forms the basis of Bessemer's steel. (!)

Electric Repeaters for Railway Signals.—On several of the English railways, the proper condition and working of distant signals is made known to the signalman in the station by electric "repeaters." By means of a very simple arrangement—1st, the raising or lowering of the signal makes or breaks a circuit which shows or repeats the same operation on a model of the signal in the station. If the wire or other apparatus leading from the station to the signal is out of order or fails to work from any cause, the model also fails to work, and the danger is at once discovered; 2d, at night, the light in the signal is arranged to heat a piece of iron above it. If the light goes out, the piece of iron cools, contracts, and so breaks a circuit which at once covers up or puts out a corresponding light in the signal station. A similar apparatus could be well, and in the long run economically applied to testing the condition of switches where trains have to pass them at speed.

Railroad Track-Layer.—This machine is said to have laid from 1 to 2 miles of track in 12 hours on the Vallijo and Sacramento Railway. The contractor is of the opinion that it may be so improved as to lay 5 or 6 miles per day—or 12 times as fast as by hand.

The machine is a car 60 feet long and 10 wide. It has a small engine on board for handling the ties and rails. The ties are carried on a common freight car behind, and conveyed by an endless chain over the top of the machine, laid down in their places on the track, and when enough are laid a rail is put down on each side in proper position, and spiked down. The track-layer then advances, and keeps on its work until the load of ties and rails is exhausted, when other car-loads are brought. The machine is driven ahead by a locomotive, and the work is done so rapidly that 60 men are required to wait on it.

Bridging the Connecticut River.—Messrs. A. D. Briggs & Co., of Springfield, Mass., have made a contract with the Shore Line Railway Company to build the drawbridge across the Connecticut River at Lyme. The bridge is to consist of 5 spans of 175 feet each, 3 of which will be east of the draw and 2 west. The length of the draw is to be 275 feet, and allowing 35 feet for the central pier leaves 120 feet clear. The piers are to be made of cast-iron cylinders, each cylinder to be driven over a cluster of 12 piles, and the interstice filled with concrete. The draw is to be of iron, and the rest of the bridge will be constructed on the Howe plan. The cost of the whole structure will be about $200,000.—*Railway Times.*

Ohio Bridge at Louisville.—The iron railway bridge now in course of construction between Louisville, Ky., and Jeffersonville, Ind., will be just 1 mile in length. It will have 24 spans; 2 of these will be 370 feet each, and 6, 245.5 feet each. Excepting on the longest spans, the rails will be placed on the tops of the girders, these being of the class known as the Fink truss. The estimated cost of this bridge, which is to be completed by September 1, 1869, is $1,600,000. The chief engineer of the work is Mr. Albert Fink, and the assistant engineer, Mr. F. W. Vaughan.

Chicago River Tunnel.—This work is approaching completion, and is to be opened in the spring; cost $500,000.

PEAT FOR LOCOMOTIVE FUEL.—The following is the report of a commission sent out by English capitalists to test the value of peat as a fuel for the purposes of running the Grand Trunk Railway in Canada:

Number of miles run by train....	683
Aggregate distance run by all the cars	15,267
Average number of cars per train	22.4
Peat consumed, in pounds......	48,475
Wood, in pounds, for same work	105,187
Number of miles run per ton of peat	31.6
Number of miles run per cord maple wood	27.6

Experiment in favor of peat, 14 per cent.

A RAILROAD QUESTION.—The Grand Trunk Railroad being in a state of complete wreck, owing to the miserable mismanagement and corruption that has prevailed in its direction, the question is whether the railway commissioners, 3 in number, who are appointed by the State to make frequent inspections of the track and of the service of the railways, and to report all defects and abuses to the proper authority, are liable criminally on indictment for murder, as accessories before the fact, should death result from the running of trains over roads left in such a condition by their negligence.—*Springfield Republican.*

AN UNDERGROUND RAILWAY IN PARIS is to be built, more with the view of bringing in market produce from the suburbs than for the purposes of passenger traffic. It is to start from the Halles Centrales, at the extreme end of the Rue St. Honoré, and take the line of the quays as far as St. Cloud, whence it will proceed to La Marche, famous for its steeplechases, where an immense station is to be constructed, which will form the starting point of a new circular railway passing entirely round Paris at several miles distance.—*Railway News.*

SINGULAR RAILWAY ACCIDENT.—A 1,600 feet tunnel on the Marietta and Cincinnati road, caved very badly during excavation, and was filled in, over the arch, with 8,000 cords of wood (!), which recently took fire, burned the stone to lime, and filled up a great part of the tunnel.

THE GAUGE QUESTION.—The laying of a third rail for narrow gauge trains, throughout the length of the Erie road, is said to be decided upon. Engineers long since estimated that the saving of expenses on the narrow gauge, would, in say 30 years, pay for the change of track and equipment. But it is possible that the introduction of steel rails will enable the wide cars to carry weight in proportion to their width without injury to the permanent way, and that the railway of the future will be wider than 4 feet 8½ inches.

NEW RAILROADS IN GEORGIA.—State aid having been granted, the "air line" road from Atlanta to Charlotte, N. C. (traversing the gold belt), is likely to be built. The Northeastern road, connecting Atlanta (and Augusta) with the Tennessee roads, is also being pushed forward. The Macon and Brunswick road is nearly completed. Branches of the Southwestern, through the fine cotton region, are also in progress.

NEW RAILWAY ACROSS EGYPT.—The new route by rail from Alexandria to Suez, by way of Zagazig, was opened in October. The former route by rail was from Cairo to Suez, the distance from Alexandria to Cairo being traversed by canal and the Nile, or by rail; but this making a considerable detour, and lengthening the journey. The entire length of the new route is 85 miles.

INSURANCE TICKETS.—As long as cars are warmed by coal stoves, and combustibles are mixed up with general merchandise, passengers should provide themselves with stamped and directed envelopes, buy insurance tickets at stations, and post them to their friends before consigning themselves to etc., etc. Otherwise their evidence of insurance will be burned up with them.

PENNSYLVANIA RAILROAD MANAGEMENT.—"The watchful forethought which provides for every emergency, and the energy with which all works essential to the accommodation of the public on this road are prosecuted," is the just comment of the "Railway Times" on the rebuilding of 5 spans of the Harrisburg bridge in 12 days.

Quadruple Tracks.—The Midland Railway has 4 lines of rails from London to Bedford. The North-Western has 3 lines for 46 miles out of London, and the Great Northern will soon have 3 lines for 22 miles.

The New Haven and Northampton R. R. Co. at the expiration of its lease to the New York and New Haven, in June, 1869, will equip it with new material throughout, and will extend the Collinsville branch to New Hartford.

OBSERVATIONS ON THE WOOLF ENGINES

RECENTLY INTRODUCED INTO THE FRENCH NAVY.

BY VICE-ADMIRAL LABROUSSE.

Translated from Annales du Génie Civil.

Note by the Editor of "Annales du Génie Civil."—A question of great importance is agitated in the Special Commissions of the Marine; that is, the adoption of a better type of engine for the vessels of the fleet. This question also touches so very nearly the interests of the commercial marine, and the great works for the construction of steam engines, that we cannot neglect this occasion to make known to our readers the different opinions held by men whose opinions and works have greatly contributed to place our marine in the first rank.

We repel the idea that in such grave circumstances, in which it is proposed to render general a system, good or bad, which involves the outlay of many millions, personal influence can prevail, and an erroneous system be adopted, because it comes from a high quarter, with the prestige of a name that generally is accepted as a guaranty of truth. To abandon frankly a theory when facts demonstrate that it does not realize the results expected from it, is a rule of conduct among engineers who are ambitious to achieve real progress rather than momentary celebrity. The real progress is generally attained by experience gained in contending with the practical difficulties that are met in attempting to carry out theories.

In publishing (April, 1867) the paper read before the Academy of Sciences by Mons. Dupuy de Lôme, and in publishing now that by Vice-Admiral Labrousse, we give our readers the means to form a clear opinion of the two systems which are placed in competition. We think, with the majority of competent judges interested in the question, that the Woolf system, applied to marine engines, has no advantages, and many inconveniences; and, without adopting the violent criticisms which the English engineer Burgh has made on the engines of the "Friedland," in the "Engineer" of August 23, 1867, we think that the paper of Admiral Labrousse, by its numerical results, sustains the conclusions of Burgh.

The "Friedland's" engine has three cylinders operating on cranks 90° and 135° apart. In the middle cylinder the steam is at full pressure, for .8 of stroke, and is then cut off. It is exhausted into the two other cylinders of the same size; and when released from them into the condenser, it has double its initial volume, and half its initial pressure. The cylinders are 84 inches diameter and 52 inches stroke, and work at 56 turns per minute; and the mean pressure in the high-pressure cylinder is computed at 33 inches of mercury.

Observations of Admiral Labrousse.—Several journals have published a note of Mons. Dupuy de Lôme on the engines with 3 equal-sized cylinders, with steam direct from the boiler admitted into only 1 of them, which note had been communicated by him to the Academy of Sciences. Though that note contains, on several essential points, and even principles, assertions in which we think there are grave errors, we should abstain from examining it critically if the question had not a serious importance in relation to our naval material, and the precedents it might establish were not likely to be too much relied upon.

In July, 1863, a commission, composed of Vice-Admiral Labrousse, president; Mons. Sabattier, engineer of the marine; Mons. Guesnet, sub-engineer of the marine; and Mons. Testard du Cosquer, lieutenant, was directed to make comparative experiments on the engine with 3 cylinders, and on the ordinary engine with 2 cylinders.

These experiments had great interest; for it was desired to know whether to commit the imperial marine definitely to the 3-cylinder system, as applied in the Friedland, or 3 cylinders acting independently; or to adopt in 2 other frigates then in progress, ordinary 2-cylinder engines of equal power.

The duration of each experiment was 12 hours. Dispositions were made to work the engines either in the way for which they were constructed, with steam admitted directly into only 1 cylinder, or in the ordinary way. In the latter case, the ports of the middle cylinder were stopped, and the valve removed, so that the steam could go directly to the outside cylinders after passing through the valve-chest of the middle cylinder. The engine was thus transformed into an ordinary 2-cylinder engine, but with some disadvantages attendant. 1st, that the steam on its way to the cylinders had to circulate in the pipes and valve-chest of the middle cylinder; 2d, that they had to work 2 cranks set 120° apart, instead of 90°. The experiments were made alternately, with the machine in its normal condition, and thus transformed. All precautions suggested by experience were taken to arrive at results as minutely exact as possible.

The general result of the trials was an economy of 3 per cent. of the fuel in favor of the new system. But in the 2 last trials which the commission deemed more comparable between themselves, this economy rose to 7 per cent.

Being directed to express its opinion on the comparative utility of the 2 machines for use in war vessels, the commission, after balancing their advantages, decided in favor of the 3 cylinders. But, notwithstanding the saving of 7 per cent. of the fuel, they advise that in the 2 vessels of 1,000 horse power about to be engined, the 3 cylinders should be arranged to work independently, but capable of rearrangement to work on the Woolf system, if new experiments on a larger scale should show farther advantages in that system.

In consequence of that advice the engines of the Gauloise and the Revanche have been constructed with 3 independent cylinders, with provisions for making the change suggested.

The note cited presenting, as an important progress, the use of "engines with 3 equal cylinders with steam admitted directly into only 1," of which the engine of the Loiret presents the first specimen, there may be a disposition to conclude that the commission has erred in its appreciations; and that in recommending engines with 3 cylinders of the type of the Gauloise in preference to those of the type of the Loiret and Savoie, it might lead the administration of the marine into a way that would be regretted.

Now, there is no danger of this. The last comparative experiments made under the same conditions, between the engines of the type of the Magnanime and the Savoie, and those of the Gauloise type, proved incontestably the superiority of the latter; and, consequently, fully confirmed the conclusions of the commission. As will be seen, that proof is easy to be apprehended, and will not escape those who have opportunity to judge of it. To render it more clear, we will follow step by step the author of the note, in the parallel which he draws between his engine and that with 2 cylinders.

The advantages which he claims in favor of the 3-cylinder system are: 1st, economy of fuel; 2d, the faculty to increase the number of turns that may be given to the screw without gearing; 3d, the almost complete balance of the movable parts around the shaft, whatever may be the position of the vessel in rolling. We propose to demonstrate that, compared with the 2-cylinder engine, these advantages are null, or much exaggerated; and that compared with the engine with 3 cylinders independent, the new machine, derived from the system of Woolf, is far inferior in all respects, except that of economy of fuel, in which they are sensibly equal.

1. *Economy of Fuel.*—The note estimates at 20 per cent. the economy of fuel which the new engines realize over the 2-cylinder engines. This is a mere hypothesis, which, thus far, is not confirmed by facts. In reality, if we recur to the experiments on the Loiret, which, on account of their great number and duration, are entitled to confidence, the mere economy of the new engine over the old one is but 3 per cent., and in the case most favorable for it is but 7.2 per cent. And we must further remark that the 2-cylinder engine on which the experiments were made was that of the Loiret, temporarily transformed for the purpose; and that it presented, as we have already said, in respect to the working of the steam, a

certain inferiority to the ordinary 2-cylinder engine, because of the unusual circuit the steam had to make on its way to the cylinders, and because of the irregular working.

Actually, if we compare the new system with that of the 3 independent cylinders, it will suffice to assure us that they are sensibly equal in economy of fuel, to look at the following table, which shows the results of the experiments recently made under full steam by the frigates. The Magnanime, the Savoie, and the Valeureuse have engines on the new system of Mons. Dupuy de Lôme; and the Revanche and Gauloise have engines with 3 independent cylinders:

Names of Vessels.	Gauloise.	Revanche.	Magnanime.	Savoie.	Valeureuse.
Names of Engine-builders.	Mazeline.	Forges at Chantiers.	Mazeline.	Forges at Chantiers.	Indret.
Date of Trials.	August 2, 1867.	July 25, 1867, Mean of Trials.	June 26, and July 24, 1866.	May 17, 1866.	August 26 and 31, 1867.
Pressure in inches	32.2	26.8	59.6 and 56.4	60	54
Saturation	2.57°	2.57°	2.43°	2.43°	2.42
Fuel per horse-power per hour, kilog.	1.371	1.515	1.295 and 1.285	1.622	1.409
Total horse-power	3,639	2,554	3,506 and 3,326	3,197	3,467
Number of turns	56.3	52	54.86 and 54	54.1	55.4

The consequences derivable from these figures are : 1st. If we compare together the engines built by the works of the Forges et Chantiers, we see that the Revanche, working with 3 cylinders independent, has an advantage of 6.6 per cent. over the Savoie, with the new arrangement. The Gauloise and Magnanime, by Mazeline, the advantage is 6 per cent. in favor of the new arrangement. 2d. Comparing the mean consumption of the 3 new engines with that of the 2 ordinary ones, we find 1 per cent. in favor of the former. From these we may conclude that the 2 types are sensibly equal in economy of fuel, under the conditions in which they were tried. But it should be observed that in the ordinary engines one source of economy was neglected ; since the same degrees of saturation were maintained as in the others, though the pressures averaged 28 inches lower. If the blowing-off had been proportioned to the pressure, there would assuredly have been an economy of at least 4 per cent. in favor of the old system.

We will add that, for the greater number of competent men, it is no longer doubtful that with an ordinary engine, conveniently disposed, we can obtain results as economical as with the Woolf engines.

Further : these engines were not steam-jacketed. That of the Friedland, which was the subject of Mons. Dupuy de Lôme's note, was steam-jacketed ; and on this addition, and some other dispositions, the author founded his hopes of a notable advantage in favor of his new system. As these favorable additions and dispositions are applicable to the old system, it is clear that this system can derive an equal benefit from them ; and that, consequently, they cannot affect the relative economy of the two systems.

In sum, we must consider the two systems as having shown equal economy of fuel ; and there is no appearance of that economy of 20 per cent. in fuel, which is the question in the note we have to examine. And we doubt if even this economy, were it realized, would compensate for the notable disadvantages of the new engines, as compared with ordinary engines.

Another important fact appears from the figures in the preceding table ; it is, that for pressures as high as 54 to 60 inches in the new engines, working with full steam, the power varies from 3,467 to 3,506 horses, while those of the Gauloise with only 33.2 inches, and cutting off at .4, develop a power of 3,639 horses. This power was raised even to 3,886 horses during three consecutive observations out of the nine which were made during an experiment of 6 hours and 20 minutes; the pressure then rising to 36 inches. And the Savoie, with 60 inches, developed only 3,197 horses power, while the Revanche, with only 26.8 inches pressure, developed 2,554 horses power. Hence it appears that when the new engines work at the normal and prescribed pressure of 53 inches, and no longer at that of 60, used in the experiment, they will develop a power notably less than 3,500 horses, whatever may be the energy of the fires and the production of steam; because in the trials the admission of steam was at its maximum.

On the contrary, in the ordinary engine, the power, which was kept at nearly 3,900 horses during part of the experiments, could be raised much higher without augmenting the pressure, were the production of steam sufficient to admit it during .65 of the stroke, instead of only .4, at which they then worked.

The ordinary engine, with three independent cylinders, has then, in this respect, a considerable advantage over that on the system of Woolf; for the power of this, inferior to what it ought to be, cannot be augmented except by an increase of the speed of movement, which is already excessive; while the speed of the ordinary engine, without diminishing its power, may be notably reduced by lengthening the pitch of the screw, accompanied either by an increase of pressure, or by a longer admission of steam, the pressure remaining the same, without sensible loss. The pitch, for example, could be 28.3 feet, the same as heretofore adopted for engines of this power.

In other points of view, the speed of movement, which is required to be greater in the engines on the new system than in that to which the engines of the Gauloise may be reduced for a given power, as we have explained, increases the chances of derangements in the machinery so much the more by requiring a higher pressure and temperature; so that there is a constraint to run faster, when, on the contrary, there should be less speed than in the ordinary engine, to insure equal safety. This is a grave inconvenience.

While saline incrustations present, in their formation, irregularities which are unexplained, experience proves that we cannot without danger employ pressures so high as 54 inches. In fact, in the Loiret, with 50 inches mean pressure, copious blowing-off did not suffice to keep the boiler free from incrustations, which in 96 hours of firing attained to a .4 of an inch thickness, although care was constantly taken to keep the salinometer (saturomètre) under the regulation figure of 3°. It was therefore indispensable that the new engines should be provided with surface condensers, in order that the high pressures they require should be admissible; and that condition was pointed out in 1863 by the president of the commission, for cases in which this kind of engine was persisted in.

Finally, we must foresee the time when boilers will be more or less weakened by use, and it will be necessary to lessen the pressure on the safety-valves, and work with lower pressure. In the new engines, which, even with the normal pressure of 54 inches, do not develop the power desired, there will be a diminution of power corresponding to the diminution of pressure, while in the Gauloise engines there will be the capability of maintaining full power, even with the low pressures, by allowing the steam to follow as far as may be necessary.

2. *Capability of increasing the number of turns of screws that can be obtained without gearing.*—To prove this capability, M. Dupuy de Lôme depends on the assumption that while the effectiveinitial pressures in his engine is 38.4 inches, that in the 2-cylinder engine must be 75.2 inches. Without examining at this moment whether the initial effective pressure will be under all circumstances 38.4 inches in the new engines, it is easy to see that the author commits a manifest error in estimating at 75.2 inches the pressure in the 2-cylinder engine working under the conditions indicated. In effect, this is his reasoning: "With an engine with 2 cylinders equal in diameter and length to those of the 3-cylinder engine, and making the same number of turns, it would be necessary to increase the mean pressure in the ratio of

3 to 2 : it would then be 50.4 inches instead of 33.6. But to obtain this mean pressure of 50.4, even with an admission of .7, and a back pressure of 4 inches, it would be necessary that the initial pressure should be 79.2, giving 75.2 inches effective pressure."

The first of these assertions is very exact; but the second is absolutely inadmissible. It is true that the mean pressure ought to be 50.4 instead of 38.4 inches; but it is easy to see by the diagram, that to obtain a mean pressure of 50.4 with an initial pressure of 79.2, it would be necessary that the line of pressures should assume a special curve, which could not be produced except on the double condition of close throttling and cutting off at .2 or .3 of the stroke. In the case we are discussing, cutting off at .7, we are far from this last hypothesis.

As to throttling, we need not have recourse to it: for it is too generally admitted, contrary to an opinion that has long prevailed in the marine, and that the author of the note seems still to hold, that throttling is disadvantageous, since even in the condition in which he places it, the loss of power by it would not be less than 10 per cent. And to get a mean pressure of 50.4, the boiler pressure would be raised, not to 83.6, but only to the point necessary to get the mean pressure proposed, with the valves wide open, as has usually been the practice; and in that case we should have a diagram of the usual form. Under these conditions it will be seen that for a mean pressure of 50.4 the maximum will be 56 inches in the cylinders, and about 34.8 in the boilers above the atmospheric pressure.

In what concerns the engine with 3 independent cylinders, the maximum pressure according to the diagrams would be 54 for a mean pressure of 33.1 inches. And, even according to this mode of computation, the maximum pressures in the 2-cylinder engines would exceed that in the new engines by only 17.2 inches instead of 36.8, as assumed in the note, and by only 14.8 inches in the engines with 3 independent cylinders, an excess that could easily be made to disappear, as we have before shown.

But this mode of computation is absolutely inadmissible, because it takes no account of the inertia of the reciprocating parts. In effect, during the first half of the stroke, the pressure on the joints of the connecting-rod is equal to that on the piston, minus what is necessary to give to the reciprocating parts the speed required by the movement of the crank. During the last half, on the contrary, the pressure is equal to that on the piston, plus what is necessary to extinguish the speed, or the *vis viva* generated during the first half of the stroke.

Calculations of all the particulars of this nature involved in the three types of engines, show that the new engine has an advantage of only 10 per cent. over the 2-cylinder engine; that is, in the ordinary 2-cylinder engine the maximum pressure is only 10 per cent. greater than in the new engine; and in the engine with 3 independent cylinders the maximum pressure is a third less than in the new engine. These consequences singularly attenuate the importance which the author hopes to draw in favor of his new engines, from the consideration of the more equable pressure on the gudgeons and crank-pins, as compared with the ordinary 2-cylinder engine; and they show, in this respect, a great advantage in favor of the engine with 3 independent cylinders—a double result which appears not to have been foreseen.

3. *Static Equilibrium.*—The third advantage claimed by the author in favor of the new engine is, "the almost complete static equilibrium of the moving parts around the shaft."

This assertion is evidently exaggerated, for the fixing of the 3 cranks at 90° and 135° distance affects notably (in the ratio of 1 to 1.4) the static equilibrium in question. If, in this respect, we compare the engine of the Friedland with 2-cylinder engines, which are counterweighted, as in the practice of Mazeline and Indret, it is easy to see that the latter are in the best condition of static equilibrium; and that if one them had been set up in the Champ de Mars in the same manner as that of the Friedland, it would have shown results superior in this respect.

As to the engines with 3 independent cylinders, they also are manifestly in the best condition of static equilibrium, since their cranks are fixed exactly at 120°.

Finally, if we consider the variations of the *couples of rotation*, it will appear, from the curves which represent them, that there is a considerable advantage in favor of the engine with 3 independent cylinders; and a less but still notable advantage in favor of the 2-cylinder engine. In effect, the ratio of the minimum to the maximum power during the revolution is: for the 3 independent cylinders, 1 to 1.4; for the 2 cylinders, 1 to 1.74; and for the new engine 1 to 2.56.

The fixing the cranks at 90° and 135° has more serious consequences than might be supposed. We have said that it alters in the ratio of 1 to 1.4, the conditions of the static equilibrium. An examination of the curves of rotation will show the pernicious influence which it exercises in this new point of view.

Conclusions.—Comparing the new engine, derived from the system of Woolf, with the common 2-cylinder engine, we see, from what has been shown, that the latter (placed in conditions exceptionally disadvantageous, as it was in the Loiret) consumes from 3 to 7 per cent. more fuel; a small inconvenience in itself, which is more than compensated in a war vessel by the advantage of employing for the same number of turns of the screw, a much lower pressure in the boiler, and consequently a lessened liability to incrustations—so rapid at high temperatures, and a lessened danger of eventual rupture of the boiler; or, if it be preferred to use the same pressure, a slower rotation of the screw may be adopted.

The maximum stress on the gudgeons and crank journals are greater in the 2-cylinder engine; but are not double, as the author of the note claims; and the difference, 10 per cent., is at most insignificant.

In compensation, the uniformity of the couple of rotations is more satisfactory in the 2-cylinder engine, and this engine costs less, weighs less, and occupies less room; and herein (besides the lower boiler pressure) is an important military advantage, since the excessive thickness of the armor plates now used puts great difficulties in the way of the effective armoring of the vital parts of war vessels.

Finally, since the normal pressures in the boilers are very unequal in the two engines, for a given power, it follows that when the boilers have become weak, and it is required to lower the pressure, conformably to the rules in force, that reduction will be much more disadvantageous in the new than in the old engine; for the power of the new engine will decline with the pressure, while that of the old one will remain undiminished though the pressure be greatly reduced.

After balancing their respective advantages and inconveniences, it appears that the superiority attributed to the new machine by its author, over that with 2 cylinders, is entirely contestable. But compared with the 3-cylinder engines of the Gauloise type, the new type of the Savoie falls short in all respects. In effect: 1st. They are equal in economy of fuel, nevertheless, with 23.6 inches lower pressure, the Gauloise engines have realized 400 horse power more. 2d. They offer more security in running the screw at higher speed, because the couple of rotation is more regular, and the stress on the journals is 50 per cent. less, and the strains that may arise from elevation of the temperature of the steam are less to be feared. 3d. The static equilibrium of the reciprocating parts is more complete, because of the more regular positions of the cranks on the shaft. 4th. To realize the normal power of 4,000 horses, we can in these engines reduce the speed of screw adopted in that of the Friedland, by increasing either the pressure (without exceeding the limit of 53.2 inches), or the admission of steam; while in the Friedland's engine it cannot be obtained without exceeding this pressure, or increasing the number of turns, already too great. 5th. As the normal admission in the Gauloise engines is but .4, when the boilers have become weakened, we can, without lessening the power, by cutting off later, use a lower pressure, which would be impossible in the new engines, where the admission is already at its maximum. 6th. Finally, in case of disabling one of the outside cylinders, the engine of the Friedland, in the condition in which it is worked, would be nearly in the predicament of a 2-cylinder engine with one cylinder disabled; while that of the Gauloise could disconnect either of its 3 cylinders without ceasing to be a well-connected engine.

To recapitulate: the 3 advantages which the author attributes to the new engine compared with the 2-cylinder engine—advantages which we have reduced to their just value in this case—are changed into many causes of marked inferiority when compared with the 3-cylinder engine of the Gauloise type; which possesses, moreover, the advantages of the first order stated in sentences 4 and 5 of the last paragraph. This machine, derived from the Woolf system, is therefore far from constituting an "important progress," as claimed in the *Note*. Its principal defects may pass unperceived in time of peace, because the occasions when it is necessary for the engines of war vessels to develop their full power will be rare and of short duration. But during war, for which these vessels are built, the rapid movements which require high pressure and hazardous speeds of piston will be frequently required and obtained; for the persons in charge will then very often be over-excited by sentiments which in time of peace have influence only in very rare cases of danger. Then will be revealed the serious dangers of these engines. In prospect of such eventualities, we should not hesitate to transform them without delay into engines of the Gauloise type, which, happily, can be done without difficulty. This type begins to increase in the English fleet (the type of the Octavia, by Maudslay); and the Commission of the Loiret, in recommending it in 1863, in preference to that which the *Note* sought to establish, indicated to the administration one of the best ways that it could follow. That is what we have endeavored to demonstrate here: and we hope we have done so by satisfactory evidence.

WOOD PAPER.—David Adam Fyfe, of Edinburgh, patents methods of preparing paper pulp from wood, etc. According to this plan the wood, reduced to thin shavings, and cut into suitable lengths, is boiled under a pressure of about 10 pounds per square inch, first with a solution of caustic soda, and afterwards with a weak solution of sulphuric acid. Next, the macerated shavings are subjected to a crushing or opening out process, and the fibre obtained is submitted to action of a washing and beating engine, the water used in this engine being rendered acid by the addition of about 1 part of sulphuric acid to each 30 parts of water. Finally, the fibre, whilst still saturated with acidulated water, is put into a bleaching engine charged with a solution of chloride of lime; and in some cases air forced in by a fan or pump is caused to pass up through the fibre whilst it traverses the race of the bleaching engine, thus facilitating the process of bleaching. The patent includes the apparatus to be employed in carrying out the above mode of treatment.

SHIP CANAL TO PARIS.—The "Revue Moderne," of Paris, opens up an old French idea, which was also a "Napoleonic idea"—that of making Paris a seaport by a canal to Rouen and Havre *via* the Seine. It was one of Vauban's projects, and it was encouraged by various monarchs. The present projectors say that large ocean steamers could reach Paris by canal, taking the freight at that city and the coal at Havre. It is proposed that government shall guarantee $4\frac{1}{2}$ per cent. to the Canal Company, and that the excess of the proceeds over 6 per cent. be kept down by reduced rates. Remarkably enough, the ancient blazon of the city of Paris is a ship. The quays of the Seine —the finest in the world—would seem to have been adapted in advance to that idea of a grand metropolitan canal, which would be one of the most arduous modern achievements in engineering.

WATERING ROADS.—A paper was read before the British Association on this subject, tracing the history of the practice from the time of throwing water from the gutters with a shovel, to the watering cart of the present day, which inadequately does the work in London, for instance, at the cost of half a million (gold) per summer. The paper states that 1 pound or $\frac{1}{2}$ pound of chloride of calcium and chloride of sodium mixed to 1 gallon of water, thrown into the watering cart, hardens and concretes the surface of a road to such an extent that no dust arises. Also that the saving of water is 75 per cent.; that the deliquescent salts are also antiputrescent; and that much cost of road repairs is saved.

CENTIGRADE TO FAHRENHEIT.—Multiply the centigrade degree by 2. Subtract one-tenth of the product from the product itself, and add 32 to the remainder. The result will be the Fahrenheit degree.

SEACOAST DEFENCES.

THE QUESTION OF MASONRY FORTS—MONCRIEFF'S SYSTEM OF PROTECTING GUNS.

The recent experiments on ordnance against armor at Fortress Monroe and at Fort Delaware have repeated the fact so often and so fully demonstrated at Shoeburyness, that adequate fixed iron defenses are *costly* to an extent that may, with our extensive coast line, absolutely prevent their general introduction. The experiments have also established other facts of importance to which farther reference will be made.

The experimental targets at Fortress Monroe were—*First*, an open embrasure of earth, strengthened by iron about the throat, designed as a modification of the barbette system, and intended for the protection of gunners and guns firing over earthen parapets. Mere earthen slopes would be too flat to afford any protection. An iron shield, with a notch in the top, forming an embrasure for the gun, was, therefore, set into the earthen embrasure. This shield was composed of solid plates 12 inches thick, supported at the back by 2 posts and a cross beam, each 12 by 15 inches in section, and embedded at the bottom and sides in an internal wall of masonry. Three spherical shots from the 13-inch gun, and one from the 15-inch gun, broke up the plates and the vertical beams very badly. The horizontal beam was not broken, but the internal walls and their iron clamps were shattered.

The more important experiment was upon a casemate having an iron front or shield. Instead of the ordinary wall pierced with an embrasure, the front of the work consisted of 2 heavy piers, one of stone and one of brick, 14 by 16 feet in plan, and 11 feet apart, this intervening space being closed with the iron shield pierced for the gun, and the covered casemate for the gun being formed of rear piers and arches in the usual manner. The shield was composed of two 12-inch plates about 4 feet wide on each side of the embrasure, each plate being supported by two 12 by 15-inch vertical iron posts in the rear. To close the bottom part of the opening between these plates, a 15-inch plate, made up of 2 thicknesses of 7½ inches each, was set up outside of them, forming the sill of the embrasure, and another narrow plate formed the lintel. The whole was secured by suitable bolts.

The shield presented an area of 11 by 12 feet, and received 6 shots at 150 yards range, viz.: 3 steel balls of 480 pounds, and one cast-iron ball of 450 pounds from the 15-inch smooth bore, the last 3 being with the maximum charge of 100 pounds of powder; and 2 shots from the 12-inch rifle, one of them a 658-pound steel bolt, with 70 pounds of powder, and the other a 658-pound chilled iron bolt with a 64 pound charge, representing 500 yards range. One of the shots struck a lintel over the embrasure, breaking it in two; the others struck in most instances upon the weakest parts of the shield, and without perforating the 12-inch plates threw off fragments from the rear of the plates, though to no great distance, and which would have been stopped by an inner skin. 2 of the iron posts, to which the armor plates were fastened, were broken clean across, and a third post in 2 places, the fragments being thrown down. Other shots were fired at the masonry with charges representing 1,000 to 500 yards range. The brick pier, at the close of the trial, was a mass of ruins outside, while the stone pier, though badly damaged on its face, showed no injury within that need seriously impair its defensive capacity. The most important damage to the stone pier was at the angle where it joined the iron shield, it having been struck by an oblique shot. If the shield had been built farther into the pier, this injury would, probably, have been less serious.

It is but just to General Barnard, who designed the work, to state that 3 years ago, when it was planned, no equally heavy armor had been destroyed by English ordnance, and our own heavy guns had not been tried with their present enormous charges.

The other experiments at Fortress Monroe were as follows: An embrasure planned by the late General Totten, consisting of the usual masonry with a throat of plates or bars 8 inches thick, received 8 shots from this heavy ordnance, and was badly shattered both without and within.

The experiments at Fort Delaware, December 3d, were designed to test another manner of strengthening an existing embrasure by iron armor. One of the Totten embrasures of the fort was opened out to a hole 8 feet wide by 6 feet high, and lined by 1-inch iron plates. Inside the opening was set up a solid 8-inch plate backed by a 7-inch plate made in 2 pieces. The 15-inch shield thus formed was pierced by a 3 by 4 feet embrasure cut out of the solid iron, with rounded corners, and was supported in the rear, at each side, by a bracket extending from the top to the bottom of the casemate, and built into the masonry. The bracket was made of vertical and horizontal 1-inch, and $1\frac{1}{2}$-inch plates riveted together like a compound girder.

A 624-pound chilled iron shot, with a 64-pound charge (representing 70 pounds at 500 yards range), was fired from the 12-inch rifle at 150 yards range, and 1,180 feet initial velocity, and drove a clean hole through the 15 inches of iron. The second shot, a 15-inch steel ball with 84 pounds of powder, shattered the rear of the shield, but did not penetrate. The third shot, a 15-inch cast-iron ball, did less damage, but knocked pieces off the rear of the shield. Three 15-inch balls and one 12-inch rifle shot were then fired at the masonry—the unbroken wall of the fort, which was found to stand better than the isolated masonry structures before mentioned. The 1-inch linings of the embrasure did good service in keeping out splinters. The box-bracket supports held on well, and proved, what has often been proved at Shoeburyness, that this is the best construction for backing and supporting shields. The plates, however, were very defective. They were rolled at Pittsburgh, from piles of $1\frac{1}{4}$-inch plates, out of iron considered good for machinery purposes, but evidently too hard for armor. The English experience long since proved that iron having the highest tensile strength, is unfit for resisting sudden blows, and that hard steel plates are quite worthless for this purpose. Hard plates are cracked like glass. Soft plates are bulged and distorted, but they *keep out the shot.* The plates referred to were also badly welded; this was shown by the complete separation of the $1\frac{1}{4}$-inch laminæ at the fracture.

The question then arises, can our coasts be protected by any other means than perpendicular walls of either iron or masonry? General Barnard says on this subject in a letter to the "New York Times": "I feel confident that every engineer would most gladly substitute earth for crumbling granite; far more gladly, indeed, than to resort to a material so costly as iron and, *as yet, so unsatisfactory.* Earth is the cheapest of all materials, and the best possible medium to resist cannon shot. Let any one, however, look at a 15-inch or a 20-inch gun mounted behind an earthen parapet, and he will recognize that those who load and direct these ponderous weapons *are scarcely protected at all*, and this defect is not remedied by forming an earthen embrasure. Unless, therefore, the battery be very high, earth *alone* is entirely inadequate as a protection for guns or gunners. Again, it frequently occurs that very limited but most important sites are to be occupied, such as the artificial sites at Spithead, England, and many on our own coast, which afford insufficient space for the requisite number of guns in ordinary earthen batteries, and which are so low that such batteries are quite inadmissible."

But another system of protection—Captain Moncrieff's system of gun-carriages—recently tried at Shoeburyness, has made a considerable commotion in foreign military circles, and may be destined, in some form, to prevent the great extension of the old system of fortification, although probably not to supersede the use of the defenses at present constructed. By this system the force of recoil is utilized for the purpose of putting the gun and gunners out of danger, by sinking the gun below the parapet, and that force is stored up by means of a counterweight, to relift the gun to the firing position when reloaded. And by means of mirrors, aim can be taken and the gun discharged without exposing the gunners to any direct aim from the enemy, whether riflemen or others.

Says the "Army and Navy Gazette": The late trials have had for their object less to test the general working of the carriage—which a very few rounds at Woolwich has shown to be satisfactory—as to try whether in respect of facility of working, rapidity, accuracy, and power of sustaining rough usage, the system would furnish satisfactory results. All these points had, one by one, been urged as objections to the system, and one by one have had to be abandoned. The 7-inch $6\frac{1}{2}$-ton gun has shot just as accurately from the Moncrieff carriage as it is capable of doing when mounted in the ordinary way. It has shot well not only at a fixed but at a moving object—thus disposing also of the objection that the carriage would be difficult to manage. On this point further satisfactory evidence is afforded by the fact that three men managed the 22-ton gun, counterweight and carriage, with ease and very fair rapidity. With a full detachment, a rate of fire of one round in 1 min. 32 sec. was attained at a moving object. We have little doubt that it will be found practicable to serve and fire guns mounted on this system at a rate not exceeding a round a minute.

It cannot be doubted, says this authority, that the Moncrieff system is destined to revolutionize the art of defense, except in positions where earthworks are not permissible; positions such as shoals, or spits of land ; or for sea forts like the Plymouth breakwater fort.

We may assume that earthworks will take the place of masonry and iron shields ; and that behind these earthworks will be placed Moncrieff batteries. Or better still, earthworks themselves will disappear and give way in large measure to gun-pits, from which the guns would rise, deliver their fire, and disappear, leaving no mark for the enemy's fire or tangible object of attack. A more embarrassing position for an army advancing through what is deemed an undefended country, and finding itself suddenly face to face with an invisible fortress, cannot well be conceived. But that is the prospect which the adoption of the Moncrieff battery holds out to us ; or we have the prospect of an unbroken line of earth parapet, from behind which at uncertain intervals guns will keep popping up. The defenders in both cases would be absolutely secure against horizontal, and only slightly exposed to vertical fire. Or, if great stress be laid on security against vertical fire, a simple mechanical arrangement can easily be applied which would make gun and gun-pit quite snug. And the important feature of the system is that batteries on this plan can be improvised at a short notice. No expensive or elaborate concrete foundations are required, owing to the absence of a horizontal destructive strain upon the platform or racers (the strain being absorbed by the recoiling carriage); and the creation of a little fortress of gun-pits might be left until war was imminent, so long as we had in store plenty of guns and Moncrieff carriages to place in them.

The unprofessional writers in England, however, go to ridiculous lengths in praising the new system, and decrying forts and all that military science has heretofore accomplished. Says a writer in the "Saturday Review," we have spent £5,000,000 upon works that Captain Moncrieff's discovery had already rendered useless and worse than useless. To which a writer in "Engineering" responds in defence of forts, as follows ; With all the advantages of the Moncrieff "discovery," forts will be just as necessary as ever they were. One of the great objects of defensive works is *an obstruction to the enemy*, which neutralizes his efforts and delays him at points where his power is the least, under the most effective defensive fire; and a means of directing upon him shot, shell, or musketry fire, from a commanding position on every point within range of the defensive weapons. The guns in these constructions may be in casemates or in open batteries. Captain Moncrieff's invention will not enable us to dispense with constructions such as these.

For example, say that a strong force were determined to seize a battery of Moncrieff-mounted guns in a pit—which *is* a species of fortification—they, meeting no hindrance but the shot from the guns, might very quickly, though with decided loss, seize the guns and gunners, while 3 times the same number of men would not be able to seize the same number of guns in a well-fortified position.

Let us suppose a fortress constructed on modern principles—with a glacis, ditch, and covered way. The march of the storming party must be up the inclined plane of the glacis, every inch of which is exposed to the full sweep of the musketry fire from double lines of sharpshooters, on the covered way, covered by an indestructible parapet — the whole breadth of the glacis — and the artillery on the ramparts inside the ditch. It is surely clear to those disposed to think, that an assailant in forcing its way under these conditions up to the ditch, would have suffered far greater loss than in marching up to the edge of a gun-pit. In the latter case his effort would have attained its object; in the former, by far the most dangerous part of the struggle would be only commencing. By escalade, "the most desperate of military undertakings," would be the only chance of ensuring success. While lowering their ladders into the ditch, descending, and raising them against the escarp, the loss of the assailants from the musketry of the *enceinte* and the artillery on the flanks playing upon them with terrible precision, must be fearful. Add to this the reception they would meet with the point of the bayonet when they reached the top of the ladders, with the certainty of many of these, with their human loads, man closely following man, being hurled into the ditch, crushing or demoralizing all below, while the musketry and artillery of the place are continuing to pour upon them their deadliest fire. It is surely unnecessary to follow the scene to greater length, though this is not its end, to prove the immense difference between the defensive power of a well-fortified position and an extended gun-pit.

This authority concludes, that the earlier adoption of the Moncrieff system would not have superseded the necessity for any of the late defensive works in England, but admits that it will greatly add to the defensive power of many of these works. In open batteries the security it will afford to the gun and gunner will be of immense value, and where in these the embrasures would have required iron shields, it is possible £1,000 a gun may be saved by the adoption of the Moncrieff carriage.

Says General Barnard, in the acticle before quoted: Until something is *established* with regard to future construction, we must try to make the best use of such means as we have, and including among them earth obstructions, torpedoes, floating batteries, etc.; and, though last, perhaps not least, the newly devised carriage which I should call the "Moncrieff" were it not that a model by an American "engineer" officer, on precisely the same principle, has been in existence for many years, and that other plans to accomplish the same purpose have been under study, and even trial, with us during the last year or two.

Mr. Bridges Adams, after describing Moncrieff's system, says: So far all appears perfect. The weight of the simple gun is multiplied into a machine tripled or quadrupled without any advantage as a gun of position, but with considerable disadvantage as a weapon of attack, by reason of that very weight, *unless by the use of rails.* The mark is rendered more difficult to aim at, but there is a mark, and a very prominent one, in the form of a mirror, and unless the gun can be made to change its position after every shot, a concentrated fire may be brought to bear upon it as soon as it rises. The guns should therefore be on rails for lateral movement. Any attacking force using the same guns, would have to lay down rails in trenches, with earthwork parapets.

As a means of coast line defense a curvilinear sunk railway, armed with Captain Moncrieff's guns, would be far more formidable than any fixed forts, and far cheaper. But if made fixtures in sunken pits, they must either be covered over, or they would be destroyed by shells, for we may be sure that the process of shelling will assume quite a new phase in accuracy under this new stimulus, and that shells will be planted nearly as accurately as point blank shot, by vertical fire, and even from ships with a stable base in tolerably calm weather.

In conclusion, it should seem that the thorough examination and test of Moncrieff's system is even more important in America than in England. When an invention involving a large expenditure has run the gauntlet of the War Office and Shoeburyness, with perfect success, it can hardly be deemed an "experiment." We think this invention should be taken up at once by our Government, as a tested war machine. There is little doubt that Captain Moncrieff's apparatus would be improved and simplified by the best mechanical engineers, either English or American, and if an inducement were offered to our leading machine builders *now* to study upon it, and prepare for its manufacture, more defensive plant and machinery could be put into the field in three months than the old system could supply in as many years.

DEPHOSPHORIZATION OF IRON FOR BESSEMER STEEL.—Iron from Königshütte with 0.497 per cent. of phosphorus made a very cold short and brittle Bessemer steel. The experiment of refining the iron in a reverberatory furnace by means of jets of air forced down upon its surface with a view to separate phosphorus, led to no favorable result, as the percentage of the same increased. On puddling the iron and reconverting in a cupola into cast-iron, according to Parry's process, the percentage of phosphorus was reduced to 0.1, and the iron could be used for steel. But this reconverted iron was found to be dearer than Cumberland iron delivered at the works in Silesia, and the process was therefore abandoned. Iron when treated this way loses most of its silicon, thereby unfitting it for conversion into Bessemer steel. Chloride of calcium was introduced into the blast furnace with the view to volatilize the phosphorus as chloride of phosphorus, but the experiments led to no result, as the chlorine of the calcium salt was disengaged at far too low a temperature.—WEDDING. *Preuss. Ztschr.*

OXYGEN LIGHT.—The new light—oxygen gas mixed with ordinary street gas—is so far believed in as to be prepared for in the erection of various new buildings. Experiments prove that it is nearly 200 times more brilliant than that emitted by a wax candle, and 14 times more powerful than the illuminative of carburetted hydrogen, and 19½ times that of the gas made by the Manhattan Company, as shown by actual measurement. It is not only more powerful in brilliancy, but, compared with the ordinary gas light, many per cent. cheaper. A thousand cubic feet of oxygen will cost the consumer, it is estimated, $25, and a thousand feet of street gas, $3, or $28 for 2,000 feet of oxygen and carburetted hydrogen, which total of mixed gases is equal in their illuminative quantities to not less than 28,000 feet of the gas that is consumed in our street lamps, at a cost of $74.—*Exchange.*

THERE are 32 manufactories on the line of the Hoosac River, at North and South Adams, employing a capital of from $7,000,000 to $10,000,000, and from 3,000 to 4,000 operatives.

STEAM ON CANALS.—An old method of applying steam to the propulsion of canal boats has been revived on the Erie canal. The driving wheel is placed in the middle of the boat and rolls on the bottom of the canal, being so arranged as to rise and fall with the irregularities of the bottom. The wheel is 1 foot thick and 8 feet in diameter; the periphery is furnished with spikes or spurs, which prevent the wheel from slipping. The speed thus obtained is from 2 to 2½ miles per hour. The extra cost of the boat so furnished was $2,500, but it is believed boats can be built at less expense.

PILING PUDDLE BALLS.—By the so-called Radcliffe process, five or more puddled balls are put together into a large bloom, under a very heavy steam hammer, shingled down into a bloom, passed for a short time into a heating furnace, and rolled off into finished iron not more than half an hour after leaving the puddling furnace. "Engineering" says: "There are many iron-masters who would fear for the quality of the iron knocked down from a pile of puddle balls, with the corresponding internal cavities between them which could hardly fail to be receptacles for masses of cinder."

ICE IN LONDON AND PARIS.—The purest London ice comes from Norway. It is stored there in ice-houses lagged by 2 feet of sawdust, but it wastes 50 per cent. in transportation to the consumer. But the great bulk of the ice is used by the fishmongers and pastry cooks, and is quite impure, coming from ponds and canals. During the present season, Paris has been largely supplied with glacier ice from Switzerland.

NEW YORK MARKET BUILDINGS.—The crusade against these disgraceful and indecent sheds has commenced, and we hope the press, secular and technical, will keep it up till the whole system is reformed. The New York wharves will be next in order.

GOLD AFLOAT.—Since 1859, the United States, Great Britain, and France alone have added 2¼ thousand millions of gold coin to what was afloat before.

RAIL TESTING MACHINE.—Messrs. Wm. Sellers & Co. are building a portable drop for the Philadelphia, Wilmington, and Baltimore Railway, to be used for testing the resistance of rails to wheel blows. A 75-pound weight is raised by hand, falls 4 feet, and is caught on the recoil by an ingenious pawl, so as to strike no short blows. Each blow is recorded by an automatic counter. Some thousands of blows from this drop are considered a nearer approach to actual service than, for instance, the ton weight falling 18 feet, which has been established for steel rails.

ONE IDEA MEN.—An exchange remarks that they are seldom healthy, wealthy, or wise—nature loves variety; to which another answers: *Non omnes omnia possumus.* Concentration of thought and effort in one direction are necessary to distinguished success. Watt was not a jack at all trades—we may add—if he did invent photography as well as the steam engine.

SHIPBUILDING IN THE UNITED STATES, according to the daily press, is reviving. Before the war, 50,000 to 70,000 tons were annually put afloat; the rebellion prostrated the business totally, and since the war, builders have been very timid, and more devoted to securing favorable legislation than improved construction and good contracts.

RIVAL TO THE MISSISSIPPI.—A project is on foot to effect steam communication by water between Ohio and the Gulf of Mexico, at Mobile, passing through the Tennessee River past the muscle shoals, and connecting with the Coosa River by a steam canal thirty miles long.

WALKING MACHINES. — The "steam man" was a most impracticable device for locomotion, but judging from the newspaper accounts, the "walking passenger-car" that appeared lately in New York would seem to be its peer.

DIAMONDS, fastened into a revolving tube, are employed to drill rocks in Reynolds' machine, recently tested in Vermont.

THE BALDWIN LOCOMOTIVE WORKS have received during the past year orders for no less than 224 locomotives. These orders come from all parts of the United States and from South America, and they are being executed at the rate of 15 per month. The capacity of the works will be 20 locomotives per month when the new shops, now well advanced, are completed.

SHINGLE MACHINE.—Walker's is said to be in general favor. The peculiarity which distinguishes it from other machines is in the fact that it does not move the bolt to be sawn to the saw, and then gig it back, or carry it circuitously back to its place, but conveys the saw to and fro to bolts lying on either side of its centre.—*Iron Age.*

STEAM STONE BREAKING HAMMERS, for Lake Superior copper mining, are built by the Michigan Iron Foundry and Machine Shop at Detroit. One of the hammers is said to weigh 50 tons complete. The head falls 9 feet, and strikes a 78-ton blow.

YALE.—The propriety of changing the site of Yale College to more ample grounds is being discussed. The sale of the present location would give a net profit of $200,000 over what it would cost to buy a new and better one.

FORM OF PROJECTILE FOR PENETRATING WATER.—Mr. Whitworth, in a paper before the British Association, gave the results of experiments, which clearly prove that the flat-ended projectile penetrated both water and armor, at an angle, better than the hemispherical or the gothic end.

SPORTING—ITS EFFECT ON NATIONAL CHARACTER.—Lord Wilton attempts to prove, in a book, that only peoples among whom field sports are popular, have achieved or maintained their freedom. The "Pall Mall Gazette" takes his lordship to task as follows: "The sporting classes have furnished out all the divine right, and passive obedience, and high prerogative men. *Our liberties, sad to relate, have been preserved by tailors and cobblers.*"

KRUPP'S STEEL WORKS.—This establishment has been in operation 40 years. It occupies 800 acres of ground, 200 of which are under roof. It employs 8,000 workmen at Essen, and 2,000 more in the mines and furnaces. The following is a list of the plant and tools: 412 melting holes and cementing ovens, 195 steam engines of 2 to 1,000 horse power, 49 steam hammers, of 1 cwt. to 50 tons, 110 smith fires, 318 lathes, 111 planers, 61 end lathes and planers, 84 boring machines, 75 grinding machines, 26 other machine tools, 120 boilers, a gas works supplying 10,000 to 11,000 lights, 6 locomotives, 150 wagons, and 13 miles of railway. In 1866 these works produced 125,000,000 pounds of steel, and had sent out 3,500 steel cannon, worth $7,000,000. The daily consumption of coal is 225 tons. At the Paris Exposition a 15-inch 1,000 pounder steel gun and a steel forging 56 inches in diameter and weighing 80,000 pounds, were exhibited among the products of these works.

THE LARGEST BALLOON.—A gigantic balloon has been constructed at Ashburnham, near Chelsea, and is intended to afford the public some aëronautical experience under circumstances which will insure safety. The balloon is four times the size of that used by Mr. Glaisher, and contains 350,000 cubic feet of gas. It is nearly spherical in shape, and is capable of raising a load of 11 tons. It cost $150,000. It is raised by pure hydrogen, and is drawn down by a chain pulled by a steam engine of 200 horse power. The weight of the cable is $2\frac{1}{2}$ tons, and its length is 2,000 feet. The balloon, car, netting, ropes, and paraphernalia weigh $3\frac{1}{2}$ tons, which, with its cable, make 6 tons of permanent weight, leaving a balance of 5 tons as its available lifting power. Thirty persons are the complement the car is intended to hold, and assuming these to average 150 pounds each, a balance of some 3 tons lifting power is left in favor of the balloon.—*London News.*

STRENGTH OF CORRUGATED IRON.—We have in type valuable papers on this subject by Mr. Hart and Professor Rankine. They will appear in our February number.

MODERN ROLLING-MILL MACHINERY, instead of being the light, rough, foundry-fitted work still seen in some of the older establishments, now rivals marine engineery in solidity and exactness of construction. The results are very clearly seen in increased production, better work, and freedom from breakdowns. The new Abbott rail mill, at Baltimore, built by Matthews & Moore of Philadelphia, started off right at first, and has, without delay, breakdown, or appreciable expense of maintenance, turned out over 50,000 tons of rails the first 2 years. The Pensylvania Steel Company's 24-inch mill at Harrisburg, by the same builders, the heaviest train in this country, has been rolling steel rails for nearly a year, with equally satisfactory results. The Reading Railway Company's mill at Reading, also built by Matthews & Moore, shows an equally good record. This is, everything considered, the most thoroughly built and heavily equipped rail mill we have. Three trains, driven by separate engines, are each 23-inch, with housings suitable for 24-inch rolls, and therefore heavy enough for rolling steel rails, which was in fact contemplated when the mill was erected.

FIVE BESSEMER STEEL WORKS are now running in the United States: the works of John A. Griswold & Co., Troy (small plant, the large plant was burned in October, but is rebuilding); the Pennsylvania Steel Works, Harrisburg; the Freedom Iron and Steel Works, Lewistown, Pa.; the works of E. B. Ward, at Wyandotte, Mich.; the Cleveland Rolling Mill Company's Works, Cleveland.

HAWKINS, HERTHEL & BURRALL, Springfield, Mass., have received an order for the construction of one of their iron bridges over the river at Pawtucket, R. I. The bridge is to be 160 feet in length, with a 20-foot driveway and 2 sidewalks of 6 feet each. The cost, including masonry, will be $14,000.

OCEAN YACHT RACE.—The challenge of the English yacht Cambria has been accepted by the American yacht Dauntless, for a trans-Atlantic race for the Queen's cup won at Cowes by the America 17 years ago.

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CHEAP IRON.

The grand requirement of the age is cheap, abundant, and multiform iron; iron at such low prices that constructors can afford to substitute it for weaker and less durable materials, and that all kinds of construction for which iron or its most useful alloy, steel, are alone adapted, will be greatly stimulated. We want iron floors and fronts, iron bridges and sleepers, iron hulls, piers, and forts, and iron framing and facing in general instead of wood. We want steel rails, tyres, wheels, shafting, girders, tension rods, engines, tools and machinery to better resist the wear and strain heretofore inadequately borne by iron. And in addition to these comparatively new and vast applications of iron and steel, we want a greater reproduction of the constructions into which they enter, — *more* steam engines and boilers, more ships and railroads, more iron defences, more agricultural machines, more plant and enginery of every description.

No one thing, not even cheaper coal or cheaper bread, could promote national wealth and progress so directly and rapidly as cheaper iron, for its offices and functions are universal. It shapes, transports, constitutes the physical constructions, and is itself the frame-work of our new civilization. A greater production of iron, even at increased prices, has stimulated commercial and manufacturing enterprises. A vastly greater production at a quarter or half the present cost, would set the world forward a century in a decade.

There is no other subject connected with physical science, of such present absorbing interest, not only to the profession, but to every pursuit associated with or depending upon engineering in its widest sense. The rapid development of new processes, and the promises and expectations of schemers and experimenters in iron and steel, are the *town-talk.* And certainly it is not, as it too often has been, in periods of excitement about new discoveries, all talk. We are entitled to expect immediate results of a character so marked as to visibly better the condition of men and nations. Doubling the life of railroad way and machinery by the use of steel, involves a saving of money that must be universally felt. Reducing the cost of wrought-iron in its almost infinite forms, even to the extent of ten per cent., as seems to be promised by the Ellershausen process, is a blessing as well defined and important as a succession of good harvests.

We devote a considerable space in this number of the Magazine, to articles on various branches of the iron manufacture, and we specially call the attention of blast furnace managers to the subject of *Purifying ores.* Our blast furnace practice most requires improvement, and it would appear to be receiving the least scientific aid, and certainly the smallest amount of experimental inquiry.

Among the more or less developed improvements of the day in the iron and steel manufacture, the Bessemer process, of course, stands at the head. As each new process presents itself, the comprehensiveness of Mr. Bessemer's scheme, and the exhaustiveness of his process, become more apparent. Although soft and ductile steel cannot be produced by it from irons containing phosphorus, nor malleable steel from irons containing a large proportion of sulphur, yet from the greater number of irons in market, it produces not only good steel, but homogeneous steel, cast from the liquid state. No other direct process develops heat enough to liquify the materials treated, and hence all their products are subject to the structural defects of wrought-iron, to welds and consequent lamination under impact, and a treacherous degree of tenacity under strain. The particular feature of Mr. Bessemer's process, showing the remarkable scope and maturity of his design, is the violent mechanical agitation of the iron under treatment, as a means of promoting the intimate mixture of the oxygen and carbon. All other direct processes are defective in this particular, and hence the heat due to the chemical reaction is not rapid and intense enough to promote fluidity. This is true of puddling in all forms, and of Heaton's and Ellershausen's processes. The mere introduction of air to molten cast-iron is not the principal feature of Bessemer's invention, or rather, it is not Bessemer's invention at all; but the blowing of liquid cast-iron into spray, so that the oxygen can get at all parts of it at once—the mechanical air stirring is the essence of Bessemer's invention.

The Ellershausen process, just now attracting such great attention, and hereinafter described, is too new—its product has been subjected to too few analyses, and its *waste* to too few economical tests, to warrant unqualified confidence, although its remarkable success as far as tried, stops the mouth of the most conservative old fogyism.

The Heaton process, already the subject of endless disquisitions, if not quarrels, in the English papers, is also too little tested to warrant positive conclusions. Its advocates base their statements and arguments mostly on assumptions, and the opposition on *one* set of analyses by the oft-quoted and much pulled about Dr. Miller.

We have referred in another place to the Siemens-Martin process, a proved and established success, and to the Siemens furnace, an accessory to cheap iron and steel, of hardly less value than either of the processes mentioned.

The *refining* of iron is certainly making good progress; we wish we could speak as confidently of the manufacture of pig. This is the weak point in the great scheme of cheap iron. Bessemer may blow, and Siemens may heat never so wisely, but if our smelters do not cultivate more intimate relations with chemical and metallurgical science, the iron millennium will not dawn upon this generation.

UNDERGROUND CITY RAILWAYS.

ENGINEERING DIFFICULTIES — PRACTICAL AND COMMERCIAL SUCCESS—THE LONDON METROPOLITAN RAILWAY.

Under the title of "The Great Railway in Diluvia," "Engineering" gives a graphic account of the difficulties encountered in constructing the Metropolitan Railway, the remarkable energy and success with which they have been overcome, and the extent of the excavations, as compared with other artificial subterranean works, from which we extract the following :—

Beyond the minor troubles to which all railway engineers are born—those with committees, boards, vestries, juries, and the owners and agents of every piece of property at which they dare so much as to look—the underground railway has presented difficulties, at almost every yard, sufficient to make or unmake a professional reputation, according to the success or failure of the attempt to overcome them. The ground had to be studied everywhere, almost, indeed, inch by inch, filled as it was, at so many points, with the gnarled and interlacing ramifications of half-a-dozen gas and water works, and the less easily diverted channels of the metropolitan sewers. In one place a row of houses was ready to move bodily forward into the tunnel; in another a great sewer, although approached but at a respectful distance, was ready to burst and flood a whole neighborhood. This, indeed, actually did happen in the Fleet valley. In Park-crescent a fine house, one in a large sweep of mansions, had to be carefully measured, its every detail drawn, then taken down, and when the railway had been completed just beneath it, rebuilt as before, and so exactly that you could not possibly distinguish it from its neighbors.

The work in carrying the extension line beneath a noble row of houses in Pembridge-square, transferring the bearing of the walls of these houses to a new foundation, was of the highest interest, and displayed great boldness.

The diversion of the large sewers was in many cases a delicate operation. In some instances a 9 feet sewer is carried over, and in others under, the rails. The Ranleigh sewer is carried over a station in a cast-iron tube 9 feet in diameter, between wrought-iron girders having a clear span of 67 feet. Near the Victoria station, the level of the rails is 21 feet 9 inches below high-water mark in the Thames, and a sewer is carried over the railway in a cast-iron tube 14 feet wide and 11½ feet high. The distance from the invert of this sewer to the rails is only 13 feet 7 inches, and it was necessary to arrange the connecting flanges of the plates and the cross girders on the skew, to obtain a sufficient clearance. The tube is protected by a brick arch turned over it, which carries the street traffic. The drainage of the railway is done by pumping-engines.

One of the neatest flights of the invention of which necessity is the mother, was the taking of the extension line beneath the West London Railway, where the difference between the crown of the lower arch and the level of the upper rails was but a few inches, and this without the least interruption of a traffic of 400 trains a day. The operation amounted to taking out the "bottom" of a railway without delaying a single one of the trains almost constantly passing over it. The rails of the West London line were supported upon longitudinal sleepers, carried upon transverse timbers, projecting 7 feet on each side of the trenches that were excavated for the side walls of the low level line; between the transverse timbers the permanent girders were placed, and the side walls built up in detail to their undersides. The length of this crossing is 119 yards. In getting in the foundation of this work, considerable trouble arose from the great depth of the clay below the surface, and it was found necessary to enclose an area of about 920 feet in length, and the width of the railway at formation, with a clay puddled dam 5 feet thick, and varying from 6 to 20 feet in depth.

A little to the west of the Aldersgate-street station stands the now practically completed meat market at Smithfield, the entire area of which at the rail level is converted into a depot, through which runs the Metropolitan Widening, devoted to the service of the trains of the Great Northern, Great Western, and Midland Railways, whilst the London, Chatham, and Dover line makes a junction with it at the entrance to the depot. The size of the market within the retaining walls, which are deeply vaulted, is 625 feet by 240 feet, the vaults serving as valuable storage-room, and the whole of the depot is roofed over with a series of brick arches, turned between a system of girders, resting upon wrought-iron columns. The upper surface of this covering forms the floor of the market on the street level, between which and the platforms of the depot beneath, communication is maintained by fifteen hoists worked by hydraulic machinery, now being completed.

In structure merely, the works upon the Metropolitan Widening, the Smithfield market works in connection with the railway, the bell-mouthed junctions, the portions in which the arch of the tunnel is of iron, and others where the haunches are of iron, together with the extensive employment of iron centering, give special interest to the underground railway, even when examined by the most practical engineer.

The part of the Metropolitan Railway now open has carried its 120,000 passengers in a single day, a traffic hardly within the powers of the 6,000 cabs of London and the 600 *omnibi* of the General Omnibus Company; a traffic not often matched by that over London Bridge, and hardly ever equalled by that carried by the other 10 metropolitan railways taken collectively. There are often, at the same moment of time, 10 well-filled trains on the double line between Bishop's-road and Moorgate-street, containing 3,000 men, women, and children; yet all this vast movement underground is unseen, unheard, and in hardly more than 20 minutes, these thousands reappear in the streets, three, four, or more miles from where they dived into the earth.

A very important consideration—which the citizens of New York will do well to ponder—is that the portion of the London line already open, now *pays*—pays £1,000 per mile per week of gross traffic, and 7 per cent. dividend upon a heavy capital account.

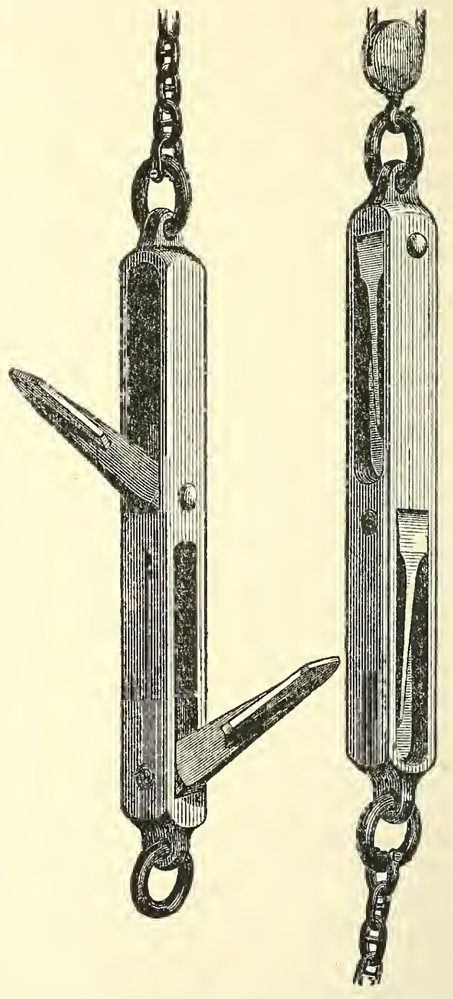
Where the line is fully completed, it will be nearly 8 miles long—a series of tunnels, as long, collectively, as the Mount Cenis tunnel, if not indeed longer, and this besides some few miles of "opens," partly in sloped cuttings, but for the greater distance between strongly buttressed and counterforted retaining walls. Although this tunnel will constitute over 20 acres of cavern—it is small compared with the deserted quarries beneath Paris, quarries now known to have an extent of more than 200 acres, and of which but a comparatively small portion is occupied by the Catacombs. Of building stone alone, upwards of 14,000,000 cubic yards are estimated to have been taken from them. None of our mines of coal or ironstone, have been yet disembowelled to anything like this extent.

"Engineering" adds,—and we beg the people of New York to attend: In New York, the third city in rank in Christendom, and where everybody is in a hurry, and where steam is turned to almost every possible purpose, there is no underground railway, nor is there soon likely to be, although the "down-town" merchants are compelled to ride four, five, or six miles each way, daily, between their homes and places of business.

The Darwinian Theory of the origin of the species is:—First, that variations so slight as not to form distinctive features of classification, are constantly occurring in the reproduction of plants and animals; second, that these variations of form are capable of transmission to progeny, the resulting characteristic generally being intensified in transmission; third, that whenever the variations give their inheritors peculiar advantages in obtaining sustenance, etc., over that possessed by their fellows, they will live longer, will procreate more, and consequently, in the lapse of ages, will extinguish the weaker types. Experiments on plants and animals conducted on this theory, have even in a short time produced astonishing differences in form, color, and habits. This theory, called "natural selection," is gaining ground among naturalists and philosophers.

WITTRAM'S ANCHOR.

The ingenuity of inventors has long been taxed, in the endeavor to produce an anchor which should come nearer than do any of the old style, to the ideal of a perfect ground tackle. The first successful attempt to improve upon the old cumbrous anchor, with its massive shank and flukes, and its huge wooden stock, was made when iron movable stocks were introduced.



The next improvement of importance was the patent known as Porter's, afterwards improved by Trotman, in which the flukes moved on a bolt in the crown. This anchor has been generally adopted in the British Navy, and also in the merchant services of various nations. Recently, Mr. Frederick Wittram, of San Francisco (now in New York city), has invented an anchor which is radically different from all others. When this anchor is not in use, the flukes lie concealed within the body of the shank like the blade of a pocket-knife, and therefore it can be as compactly stowed as a block of wood of the size of the shank, as shown by Fig. 2 in the engraving. On throwing the anchor overboard, the flukes swing out, as in Fig. 1, and no matter how the anchor falls, one or both flukes are sure to take hold, thus rendering it impossible for the anchor to drag. As there are no projections, such as the stock, or an unused arm, it therefore cannot foul as other anchors frequently do. In weight it is one-third less than ordinary anchors of equal capacity. The repeated tests which have been made of its practical utility have been all highly satisfactory, and it is now attracting much attention from scientific and experienced nautical men.

RIVETS.—Mr. Clark, the English bridge engineer, who has made experiments to determine the shearing strength of rivet iron, mentions the fact that rivets, worked hot, contract in cooling, and draw the plates together, thereby causing friction. From this he infers that the value of the rivet is greater than the shearing strength of the rivet iron by the amount of the friction. Later experiments on riveted work show, however, that the value of rivets falls below that given by Mr. Clark for rivet iron, although it includes friction also. Mr. Fairbairn, in his "Useful Information for Engineers," mentions this fact about the friction not appearing to help the rivets, but does not attempt to account for it. Mr. Reed, in his recent work on shipbuilding, explains it by saying that the friction does help the rivet, but that the rivet is much weakened by the working and by contraction during cooling. To show the extent of this, he takes Mr. Clark's values for the shearing strength of rivet iron; experiments at Chatham Dockyard supply the shearing strength of rivets in place (including friction), and some experiments made at Pembroke (which are described in the book) give the amount of the friction; and by deducting the difference between the two last from the first, he gets the amount which the rivet has been weakened. To take an example of a three-quarter rivet:—Shearing strength of the rivet iron=19·52 tons for a double shear; double shearing force of a three-quarter rivet in place=18 tons; mean value of the friction caused by a three-quarter rivet=4.6 tons, from which we find that the shearing strength of the rivet amounts to 13½ tons, or about 6 tons less than the double shearing strength of the iron from which it was made. Mr. Reed conjectures in the text that the principal cause of this loss of strength in the finished rivet is the interior stress of the iron due to the contraction, and he adds that there is probably a further reduction due to the manipulation which the rivet has to undergo in being manufactured and put in place.—*Mechanics' Magazine.*

SUPERSATURATED SOLUTIONS.—Mr. Charles Tomlinson, F. R. S., has been experimenting and theorizing upon the subject of the phenomena of supersaturation in saline solutions, and has communicated to the Royal Society his conclusions and the grounds upon which they are based. The conclusions arrived at by Mr. Tomlinson are: (1) That a number of hydrated salts form supersaturated solutions, and remain so even at low temperatures simply from the absence of a nucleus to start the crystallization; (2) That a nucleus is a body that has a stronger adhesion for the salt than for the water which holds the salt in solution, a state of things brought about by the absence of chemical purity; (3) That three or four salts form supersaturated solutions, which in cooling down deposit a modified salt or one of a lower degree of hydration than the normal salts; (4) That this modified salt is formed first by the deposit, in small quantity, of the anhydrous salt, which entering into solution, forms a dense lower stratum containing less water than the rest of the solution, in which lower stratum the modified salt is formed; (5) That salts of a lower degree of hydration form supersaturated solutions, which on reduction of temperature, or by the action of a nucleus, deposit the excess of salt that held the solutions supersaturated, leaving them merely saturated.

WELDING OF COPPER.

Translated from Dingler's Polytechnic Journal, by John B. Pearse.

Mr. Philip Rust, Bavarian Inspector of Salt Works, writes as follows: The great obstacle heretofore experienced in welding copper, has been that the oxide formed is not fusible. Now, if any fusible compound of this oxide could be found, it would render such a weld possible. We find in mineralogy two copper salts of phosphoric acid, viz.: Libethenite and pseudo-malachite, each of which melts readily before the blowpipe. It was therefore natural to suppose that a salt which contained free phosphoric acid, or which would yield the same at a red heat, would make the weld easy by removing the oxide as a fusible slag.

The first trial was made with microcosonic salt (phosphate of soda and ammonia), and succeeded perfectly. As this salt was quite dear, it was found advisable to use a mixture of 1 part phosphate of soda and 2 parts boracic acid, which answered the same purpose as the original compound, with the exception that the slag formed was not quite as fusible as before.

This welding powder should be strewn on the surface of the copper at a red heat; the pieces should then be heated up to a full cherry red or yellow heat, and brought immediately under the hammer, when they may be as readily welded as iron itself. For instance, it is possible to weld together a small rod of copper which has been broken; the ends should be beveled, laid on one another, seized by a pair of tongs, and placed together with the latter in the fire and heated; the welding powder should then be strewn on the ends, which, after a further heating, may be welded so soundly as to bend and stretch as if they had never been broken.

M. Rust had in as long ago as 1854, welded strips of copper plate together and drawn them into a rod; he had also made a chain, the links of which had been made of pretty thick wire and welded.

It is necessary to carefully observe two things in the course of the operation. 1st. The greatest care must be taken that no charcoal or other solid carbon comes into contact with the points to be welded, as otherwise phosphide of copper would be formed, which would cover the surface of the copper and effectually prevent a weld. In this case it is only by careful treatment in an oxidizing fire and plentiful application of the welding powder that the copper can again be welded. It is therefore advisable to heat the copper in flame, as for instance a gas flame.

2nd. As copper is a much softer metal than iron, it is much softer at the required heat, than the latter at its welding heat,—and the parts welded cannot offer any great resistance to the blows of the hammer. They must therefore be so shaped as to be enabled to resist such blows as well as may be, and it is also well to use a wooden hammer, which does not exercise so great a force on account of its lightness.

Hydraulic Dredging.—If sand is drawn along with water into a centrifugal pump, it will be driven forward and thrown out with the water. Messrs. Gwynne, of London, therefore propose, in order to dredge at a depth of over 60 feet for the Bermuda floating dock, to stir up the sand of the sea bottom mechanically, to place their centrifugal pump close to the bottom, and thus to excavate it—pump it out. A large wrought-iron tube, attached to the dredging barge and swinging like the bucket-frame of a dredging machine, carries a pump at the bottom. The shaft that drives the pump passes down the centre of the tube, and carries also a series of screw-blades which stir up the sand. A hood, at the end of the tube, prevents the escape of the sand, so that it is drawn into the pump while momentarily suspended in the water. The work to be done is, simply overcoming the difference of weight between sand and water, raising both a short distance above the water-line, and overcoming the friction of the mass rising in the tube.

Ichabod Washburn, who died in Worcester, Massachusetts, on December 30, has been identified with the manufacture of machinery in this country for nearly half a century. He was as generous as he was successful. Among his gifts were a fund of $200,000, a machine shop fully equipped, and $50,000 working capital, to the Worcester County Institute of Industrial Science.

COMPARISON BETWEEN THE UNIFORMITY OF BESSEMER STEEL AND IRON RAILS.

EXPERIMENTS MADE FOR THE CENTRAL RAILWAY OF ORLEANS AT THE TERRE NOIRE WORKS, AND THOSE OF PETER ASHCROFT, ESQ., ON ENGLISH IRON RAILS.

BY JOHN B. PEARSE.

Conditions.—1. Two ingots shall be taken at hazard out of the same charge and submitted to the subjoined tests in order to ascertain whether their qualities are identical. These trials shall be repeated upon three different charges.

2. Choose any charge as a typical one, and of this take one ingot and submit it to the following tests. Make 6 charges with the object of making them identical with the typical one, and of each of these 6 charges take an ingot and submit it to the same tests, and endeavor to obtain results similar to those obtained from the typical charges.

The desired tests are as follows:

1. The ingots chosen for each series of tests shall be rolled into rails in the ordinary way.

2. Each rail shall be submitted to a deflection test on the following conditions: The rail placed on supports 1 metre apart is to be submitted to pressure in a hydraulic press. Ascertain the deflection under pressure, and the permanent deflection after removal of the pressure.

The hydraulic press used was constructed at Graffenstaden and is fed by 3 pumps worked by eccentrics, whose stroke is so regulated that the supply of water shall be as uniform as possible.

3. Pieces of these rails, of a length of 2 metres, shall be tested by a falling weight under the following conditions:

The rail is placed on 2 supports, the centres of which are distant 1.1 metres from each other; these supports rest directly on a block of iron weighing 10,000 kilogrammes ($9\frac{1886}{2240}$ tons). The weight of the drop shall be 300 kilogrammes (661.36 lbs.).

The subjoined table exhibits the results obtained in the above series of tests:

First Series of Tests.

Comparison of Two Ingots from the same Charge.

TESTS UNDER PRESSURE (HYDRAULIC).	CHARGE No. 577.				CHARGE No. 580.				CHARGE No. 581.			
	Ingot A.		Ingot B.		Ingot A.		Ingot B.		Ingot A.		Ingot B.	
	Deflection under Pressure.	Permanent Deflection.	Deflection under Pressure.	Permanent Deflection.	Deflection under Pressure.	Permanent Deflection.	Deflection under Pressure.	Permanent Deflection.	Deflection under Pressure.	Permanent Deflection.	Deflection under Pressure.	Permanent Deflection.
Pressure in Kilogrammes.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.
15,000..........	1.7	0.05	1.7	0.05	1.8	0.1	1.8	0.0	1.5	0.0	1.9	0.0
20,000..........	2.2	0.1	2.2	0.1	2.2	0.1	2.2	0.0	2.0	0.0	2.1	0.0
25,000..........	3.0	0.4	2.8	0.3	2.7	0.2	2.8	0.1	2.6	0.1	2.6	0.1
30,000..........	5.2	1.9	4.7	1.9	3.5	0.5	3.6	0.6	3.2	0.2	3.4	0.3
35,000..........	10.8	7.5	8.9	5.3	5.8	2.3	6.0	2.3	5.3	1.6	4.8	1.1
40,000..........	15.8	11.9	16.8	12.6	10.5	6.4	11.3	7.2	9.8	5.5	9.4	5.2
	Kilog.	Millim.	Kilog.		Kilog.		Kilog.		Kilog.	Millim.	Kilog.	Millim.
Limit..........	55,000	60	54,100	Broke.	56,500	Broke.	56,500	Broke.	61,500	60	62,000	53

DROP TESTS.	Deflection after Blow.	Deflection after Blow.	Deflection after Blow.	Deflection after Blow.	Deflection after Blow.	Deflection after Blow.
Fall in Metres.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.
1,500...........	5	5	4	4	4	4
1,750...........	11	10	10	10	9	9
2,000...........	19	19	16	17	16	14
2,250...........	27	27	25	24	23	23

Second Series of Tests.

Comparison between Seven Ingots of Different Charges.

TEST UNDER PRESSURE (HYDRAULIC).	TYPE CHARGE, 564. Deflection. Under pressure.	TYPE CHARGE, 564. Deflection. Permanent.	CHARGE, 582. Deflection. Under Pressure.	CHARGE, 582. Deflection. Permanent.	CHARGE, 585. Deflection. Under Pressure.	CHARGE, 585. Deflection. Permanent.	CHARGE, 586. Deflection. Under Pressure.	CHARGE, 586. Deflection. Permanent.	CHARGE, 589. Deflection. Under Pressure.	CHARGE, 589. Deflection. Permanent.	CHARGE, 590. Deflection. Under Pressure.	CHARGE, 590. Deflection. Permanent.	CHARGE, 594. Deflection. Under Pressure.	CHARGE, 594. Deflection. Permanent.
Kilogrammes.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.	Milli.
15,000	1.6	0.1	1.7	0.1	1.8	0.1	1.8	0.1	1.9	0.1	1.6	0.0	1.7	0.0
20,000	2.2	0.2	2.2	0.2	2.2	0.2	2.3	0.1	2.4	0.2	2.1	0.1	2.1	0.1
25,000	3.5	1.1	2.9	0.3	3.3	0.7	2.9	0.3	3.2	0.4	3.2	0.8	2.8	0.3
30,000	11.2	8.5	4.7	1.0	7.2	3.9	5.1	1.8	5.6	2.2	11.6	8.5	5.0	1.9
35,000	23.6	21.0	10.0	6.4	16.2	12.1	11.4	7.6	15.2	11.2	25.0	21.3	12.4	8.7
40,000	40.6	36.1	18.6	14.0	29.0	24.1	20.8	16.5	26.8	22.5	45.0	40.4	22.7	18.2
	Kilog.	Milli.	Kilog.	Milli.	Kilog.		Kilog.		Kilog.	Milli.	Kilog.	Milli.	Kilog.	Milli.
Limit	50,000	80	59,000	63	50,200	br'ke	44,500	br'ke	54,000	70	49,500	74	56,200	65

DROP TESTS.	Type Charge, 564. Deflection after Blow.	Charge, 582. Deflection after Blow.	Charge, 585. Deflection after Blow.	Charge, 586. Deflection after Blow.	Charge, 589. Deflection after Blow.	Charge, 590. Deflection after Blow.	Charge, 594. Deflection aftor Blow.
Fall in Metres.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.	Millim.
1.500	7	6	4	7	6	7	5
1.750	15	13	14	15	14	15	14
2,000	26	23	25	26	25	26	25
2,250	37	31	33	37	35	37	36

The following conclusions flow naturally from the above tests :

1. The first series demonstrates the practical identity of 2 ingots chosen at random from the same charge. The regularity of the results is remarkable up to the pressure of 25,000 kilogrammes (about 25 tons), which represents quite nearly the *limit of elasticity.*

Above this limit the differences are still inconsiderable compared to weights (or pressure amounting to weight) borne.

2. The first series develops a remarkable regularity in the charges, although not made with the object of proving any identity.

Charge 581 is a little harder than the others, but the results up to the limit of elasticity do not vary much from those given by the other ingots, and the variation is too inconsiderable to have any practical influence.

3. The second series shows the practical identity of the 6 ingots with the 7 or *type* ingot. The latter is a little softer than the ingots of the 3 charges in the first series. It was made so designedly, and its qualities were reproduced quite closely, as the differences in the permanent deflection or set are within a few tenths of a millimetre. As in the previous series, the differences become great only when the limit of elasticity is passed.

4. The drop tests show uniform results, which are in harmony with those given under pressure. The variations bring out the slight differences in the hardness of the various ingots. For example, the metal of charge 581 is a little stiffer than that of charges 577 and 580. It is also apparent that the ingots of the second series were softer than those of the first.

The experiments were conducted with every care, by the engineers of the Terre Noire Works in presence of M. Delom, engineer of the Orleans road, on the part of the railway company.

These results are very interesting as showing a practical identity in the products of the Bessemer process. It would be difficult to find any such series of iron

Name of Rail or Maker.	Weight per Yard.	Weight of Ram.	Number of Blows.	Blows Increasing by Foot as under.	Result of Blows.	Turned or not, before Breaking.	Greatest Deflection whether Turned or not.	REMARKS.
DERWENT	....	300 lbs.	3	4 ft. to 6 ft.	Broke......	Not turned	5-16	Too cold short.
Do., another rail	....	"	5	4 ft. to 8 ft.	"	"	7-8	Ditto.
Do., a third rail	....	"	11	4ft. to 14 ft.	"	"	3 3-8	Both good and safe.
BARMINGHAM'S	73 lbs.	3 cwt.	2	8 ft. and 9 ft.	"	"	3 8	Bad.
Do	78 lbs.	"	8	8 ft. to 15 ft.	"	Turned ...	3 11-16	Good.
Same rail turned	"	"	6	all 15 ft.	Nearly straight	" ...	......	
Same rail turned	"	"	2	all 15 ft.	Broke......	....	1-2	
HOPKINS'	82 lbs.	"	2	8 ft. and 9 ft.	"	Not turned	1-4	Bad.
Do., another rail	75 lbs.	"	5	8 ft. to 12 ft.	"	"	1 13-16	A very good sample.
PHYMNEY	....	300 lbs.	4	8 ft. to 11 ft.	"	"	1 1-16	Rather too cold short.
Do., anotber rail	....	"	3	8 ft. to 10 ft.	"	"	5-8	Ditto.
Do., a third rail	....	"	7	8 ft. fo 14 ft.	"	"	2 3-8	A safer rail with a fine granular head.
Do., a fourth rail	80 lbs.	3 cwt.	2	5 ft. to 6 ft.	"	"	1 16	Very cold short and questionably safe.
EBBW VALE	....	"	7	all 10 ft.	" ...	"	2 5-8	
Do., another rail	....	"	7	all 15 ft.	"	"	4	
Do., a third rail	....	"	10	all 10 ft.	"	Turned ...	4 1-8	
Do., same rail turned	....	....	9	three of 10 ft., six of 15 ft.	"	....	......	
ABERDARE	75 lbs.	3 cwt.	1	5 ft.	"	Not turned	......	Bad.
Do	82 lbs.	"	1	4 ft. 6 in.	"	"	......	
Do., another rail	....	"	6	10 ft.	" ...	"	1 1-16	
Do., another piece of same rail	....	"	1	5 ft.	"	"	......	
Do	81 lbs.	"	11	5 ft. to 15 ft.	"	Turned ...	2 15-16	A very good rail, fine and granular, indicating long wear.
Same turned	....	"	2	both 5 ft.	"	....	......	
BLÆNAVON	82 lbs.	300 lbs.	2	4 ft. and 5 ft.	"	Not turned	1-16	
Do., another rail	81 lbs.	"	1	4 ft.	"	"	......	Entirely rotten or extremely hard.
Do., another rail	60 lbs.	"	7	5 ft. to 11 ft.	" ...	"	2 1-2	Very good.

rails made with puddled steel or hard iron heads. The following series of tests made by Mr. Peter Ashcroft, engineer to the South Eastern Railway Company, shows how much iron rails made by the same companies may vary in strength. The tests are classified according to the company upon whose rails they were made. The remarks are those of Mr. Ashcroft.

These trials were published in "Engineering" and have been rearranged for the purpose of showing distinctly how much the rails of each maker varied. The tests show that the majority of the rails tried excepting those of one company (Ebbw Vale) were extremely brittle and unsafe. It is very probable that the slabs which are made from old rails and used in the formation of the rail piles vary greatly in quality and may indeed be altogether different; that is, one slab might easily be cold short, while its neighbor was red short. It would not be improbable to suppose that in some parts of the country a rail pile might easily be composed of slabs from rails of 3 or 4 different makers, with tops and bottoms puddled and rolled at the mill. Now such a rail would be composed of layers of different material varying in strength, and it is quite natural to conclude that some of the layers would be so weak as to partially destroy the strength of the rail itself, by giving way before the stronger parts had been materially strained. That is, a strong flange is of no use with a web which would give way on strain, or a head which was made so hard as to crumble on the reception of a blow, or under the constant succession of blows to which it is exposed in the track. It is also probable that a pile may be so heated as to be burnt in some parts while quite sound in others, while the temperature at which it is necessary to weld the slabs together is so near that at which they may be burnt, that many tons of piles have been burnt in the furnace by the mere change of the light in which the furnace was placed. When the poor quality of iron used for rails is taken into consideration along with the manner in which the same is worked up, it is quite obvious that a great deal of irregularity is natural to the whole series of operations.

THE ELLERSHAUSEN PROCESS.

The recent and remarkable invention of Mr. Ellershausen, which is now regularly in use in Pittsburg, and is being rapidly introduced all over the country, has greatly advanced the solution of this important problem. So many new steel and iron processes are brought to notice every day, that the unprofessional reader cannot keep track of their names and aims. The value of this process may be inferred from the fact that a no less respectable Board of Trustees than Messrs. Asam L. Hewitt, E. B. Ward, Jas. Harrison, Jr., and several Pittsburg iron masters, are now granting licenses under the Ellershausen patents.

The process consists in the conversion of crude cast iron, as it runs from the smelting furnace, into wrought iron, by the simple admixture of granulated iron ore. It is carried out at the works of Messrs. Shonberger, at Pittsburg, in the following manner: On the casting-floor of the smelting furnace a cast-iron turntable, about 18 ft. in diameter, is revolved on rollers by a small steam-engine. Upon the outside edge of the table stand a row of cast-iron partitions, forming boxes, say 20 inches wide and 10 inches high, open at the top. Just above the circle of boxes stands a stationary, wide-mouthed spout, terminating in the tap-hole of the furnace. When the furnace is tapped, the liquid iron runs down this spout and falls out of it in a thin stream into the boxes as they slowly revolve under it, depositing in each a film of iron, say one-eighth of an inch thick. But, before the fall of melted iron reaches the boxes, it is intercepted, or rather crossed, at right angles, by a thin fall of pulverized iron ore, which also runs out of a wide spout from a reservoir above. These two streams or falls are of about equal volume, say one-quarter of an inch deep and 20 inches wide. A workman, with a bar in the tap-hole, regulates the stream of iron, and the iron spout from which the liquid metal falls into the boxes is removable; other spouts, previously coated with loam and dried, being attached to a common revolving frame, so as to be ready for use when the loam covering of the first becomes cracked or removed.

The thin layers of iron and ore soon chill and solidify, so that by taking away the outer partition of the boxes (which form the rim of the turn-table), they may be removed in cakes of the size of the boxes, and weighing about 200 lbs. each. Four of these cakes or blooms are put into a reverberatory puddling or heating furnace, and raised to a bright yellow heat. They will not melt at this heat, but become softened so as to be easily broken up with a bar. The four blooms are formed, in the furnace, by the "rabble" of the workman, as in ordinary puddling operations, into eight balls. The balls are brought out, one after another, squeezed in the ordinary "squeezers" to expel the cinder and superfluous ore, and then rolled into wrought-iron bars, which are now ready for market, or for further reduction into smaller finished forms.

The chemistry of the operation is as follows: The crude cast-iron contains say 5 per cent. of carbon and 2 per cent. of silicon, and more or less sulphur, phosphorus, and other impurities. In the Bessemer process, the oxygen of the air, blown into the liquid iron, combines with this carbon and these other impurities, and not only removes them, but leaves the pure iron in a liquid state, from which it can be cast into homogeneous masses of any size. In the puddling process, the oxygen of the air and of the ore, or other "fettling" put into the furnace with the iron, combines with and eliminates the impurities, which are afterward squeezed out of the pasty mass by the squeezers and rolls. This process is long and comparatively expensive, because the mixture of oxygen or oxygen-bearing substances is not made intimate with the iron except by long stirring, which is not only skilful, but exhausting work.

In the Ellershausen process, the oxygen of the ore or oxide of iron (magnetic oxide is preferred) combines with the carbon and impurities, eliminating them as in the puddling process, and the iron of the ore increases the product. The chemical combination of the ore and the liquid crude iron appears to take place partly at the time of their contact when falling and lying upon the turn-table, and partly where the reheating occurs in the furnace. It seems impossible that a reaction which is so violent in the Bessemer process, and so prolonged in puddling, should take place so quickly and quietly in the new process; but the fact that the cakes of iron and ore do not melt by subsequent heating, as cast-iron would, proves that its nature is changed by the first contact of the ore. The removal of sulphur and of phosphorus also seems more thorough than in the other processes. Analyses at different stages of the operation will throw more light on this question.

The remarkable feature of the Ellershausen process is that absolutely no skill is required to carry it out. The proportion of ore mixed is intended to be about 30 per cent; but if too much is added, it is readily squeezed out with the slag, and seems to do no harm. The subsequent heating occupies about half an hour. "Puddle bar," the product obtained from the first rolling of the product of the puddling furnace, is never marketable or finished iron. It is usually very ragged and unsound, and requires subsequent piling, reheating, and rerolling, to expel the impurities and to give it soundness and solidity. The new process appears to produce merchantable iron at the first rolling, and, at Pittsburg, from a very inferior pig-iron, made of one-half sulphurous Canada ores, and one-quarter Lake Superior and one-quarter Iron Mountain ores.

The thoroughness and rapidity of the purification by this process evidently depend on the intimacy of the mixture of iron and ore. This intimate mixture is also the essence of the Bessemer process. In fact, to Mr. Bessemer's original apprehension of this idea of intimate mechanical mixture, the greatest modern improvements in the iron manufacture are due.

The Ellershausen process is said to decrease the cost of wrought-iron from $10 to $20 or $30 per ton, according to the materials used and the form of product required. That it is a success is amply proved by regular working at Pittsburg and many experiments elsewhere; and if anything like this economy can be realized, its value to the public will only be exceeded by that of the Bessemer process. The latter process, however, produces *steel*, which is absolutely homogeneous and of regulated hardness, according to the wear and service required, and hence indispensable for rails, tires, and various machinery purposes. Any iron product that is not *cast* from a liquid state, is subject to all the structural defects of ordinary wrought-iron.—*New York Times.*

ENGINEERS IN PARLIAMENT.—"Never," says "Engineering," "have the most important industrial interests of the kingdom been so fully represented as in the new Parliament." It includes, engineers, contractors, ironmasters, manufacturers and the owners of collieries. Among them are, Mr. George Elliott, Prest. of the North of England Inst. of Mining Engineers, an ironmaster who finds employment for 10,000 men; Mr. John Lancaster, Chairman of the Mining Association of Great Britain, head of the Wigan Iron and Coal Company, and less favorably known in America in connection with Captain Semmes of the Alabama; Mr. Richard Fothergill of the Taff Vale Ironworks; Mr. A. C. Sheriff, chairman of the Metropolitan District Railway; Mr. Joseph D'Aquilar Sumuda, Shipbuilder; Sir Daniel Gooch, late Locomotive Superintendent of the Great Western Railway; Mr. John Robinson McClean, late President of the Institution of Civil Engineers; Mr. John Platt, Manufacturing Engineer; Mr. John Hick, Engine-builder; Mr. John Laird, Shipbuilder; Dr. Lyon Playfair of the University of Edinburgh; also, Messrs. John Miller, Charles E. Cawley, Sir Richard Atwood Glass, Messrs. Thomas Brassey, James Howard, and Charles Seely, Engineers, and Messrs. Bolckow, Brogden, Beaumont, Winn, Plimsoll, Rylands and Samuelson, Ironmasters.

THE UPPER HUDSON—SLACKWATER NAVIGATION.—The report of the State Engineer for 1867 embodies the report of the surveys made in 1866 by Samuel McElroy, C.E., for the improvement of the Hudson river for slackwater navigation from Troy to Fort Edward, about 40 miles, and a corresponding improvement of the Champlain Canal from Fort Edward to Lake Champlain, about 25 miles, with locks 225 feet by 30½ feet, adapted to 8 feet water-way; and also the comparative cost of improving the Champlain Canal from Troy to Whitehall, with locks 225 feet by 25, and 7 feet water-way. It appears that a dam at the Highlands, 150 feet high, would turn the stream into Lake Champlain and the St. Lawrence; that the remedy which New York harbor needs for the difficulties of navigation at

Hell Gate from the swift tidal currents, and at other points for ice fields and deposits of silt, and at Sandy Hook, would be found by connecting New York and Brooklyn with a masonry dyke say 400 feet wide, with 2 or more ship locks, and by making a ship canal of the Harlem River, so that the whole volume of the North River could go out to sea, and the present tidal flux and reflux be prevented on the East River, and the facilities of Sound and river commerce be turned into their natural channel at the head of New York Island. This would also solve effectually the problem of connecting New York and Brooklyn.

It is also proposed to examine the gorges of the Hudson river above Fort Edward, to determine the feasibility of a plan for retaining the freshet supplies, so as so prevent the periodical floods which have always proved so destructive above Albany.

The details of the report show that on a comparison of the items of cost, the sum of $4,534,379 will secure 8 feet water-way by the river plan, from Troy to Whitehall, while it will cost $5,866,851 to secure 7 feet water-way by the canal plan, and that the "commercial, military, and mechanical advantages are distinctly in favor of the river plan;" the value of the developed mill power alone being shown to be about $4,334,600.

NEW SYSTEM OF BOILING SUGAR.

In an ordinary vacuum pan, the top of the liquid alone forms the evaporating surface, and evaporation would, of course, be more rapid were a greater portion of the liquid exposed. An improvement by Mr. Tooth consists in pumping the juice down from the top of the vacuum pan, at the moment of granulation, through a rose. The juice is thus distributed in small streams through the air contained in the evaporating vacuum chamber, and the surface exposed, as compared with the old system, is said to be as 1,000 to 50. The evaporating chamber differs from the old vacuum pans in shape, being, to speak roughly, a long cylinder, with the ordinary round pan at the top and bottom. The juice, before reaching the evaporating chamber, is pumped up through a number of pipes surrounded by steam in a cylinder. The following advantages are stated by the inventor to be secured by this process: 1. The juice is protected from excessive and long-continued heat. 2. Long exposure to the injurious influence of the atmosphere is avoided. 3. Great rapidity in carrying on the evaporation is secured. 4. The juice is transferred to the vacuum pan (or evaporating chamber) immediately after defecation and filtration, avoiding the necessity of open pans. 5. Any extent of heating and evaporating surface is easily obtained. 6. The cost of fuel is greatly lessened. 7. Vacuum pans now in use may be made available for the improved system at a comparatively small cost. 8. The finest sugar is produced without the expense of animal charcoal, and the crystallization being perfect, there is no loss by drainage. 9. There is no formation of molasses beyond that naturally existing in the juice, as the temperature never need exceed 140° to 160° Fahr. 10. The system is also useful in beetroot sugar manufactories. There is an arrangement by which the clogging of the rose, through which the partly-granulated sugar passes, is remedied. The idea of exposing a greater surface to evaporation seems to us excellent in theory, but it belongs, of course, to practical men to say if it will work. Mr. Tooth has another patent to compete with Mr. Fryer's boncretor, for rapid and cheap evaporation. This consists in passing the partially granulated juice through a rose, and letting it drop down through a long cylinder or tower filled with heated air. The patentee states that the juice reaches the bottom in the shape of sugar.—*Produce Market Review.*

Another Great Eastern.—Mr. Thomas Silver has designed a ship of Great Eastern proportions except as to depth; the draft is to be 18 instead of 28 feet. The vessel is intended to carry 4 times as many passengers as the present Cunarders, and to have Christian beds and rooms for their accommodation.

High-lift Centrifugal Pump. — Messrs. Gwynne & Co., London, are constructing a centrifugal pump, to draw from a depth of 18 feet and force over a stand-pipe 114 feet high—the greatest lift yet attempted with this kind of machine. The pump has a disc 2 feet in diameter, and is to run at 910 revolutions per minute.

RECENT CIVIL ENGINEERING WORKS.

BRIDGES, HARBORS, AND DOCKS.

Compiled from "Engineering," and other authorities.

English Bridges.—In England two fine bridges were completed and opened in 1868. The great bridge of the London and North-Western Railway over the Mersey at Runcorn, besides its long approaches, has three spans of lattice girders of 300 feet clear opening each. The construction of this bridge presents no new feature of interest.

The Solway viaduct, carried out upon the plans of Mr. James Brunlees, is about a mile in length. It has 161 spans of 30 feet each of light wrought-iron girders, besides a swing bridge giving two 50 feet openings. The bridge is supported upon cast-iron piles, driven through the shifting sand into the gravel below. About 1,900 tons of wrought, and 2,300 tons of cast iron have been worked into this structure.

The new bridge at Blackfriars (pronounced by the President of the Institute of British Architects, the "ugliest bridge of its size in Europe") has a central arch of 185 feet, besides 2 arches of 175 feet, and 2 of 155 feet. The arches are of wrought iron; the foundations have been built up in caissons; the width between parapets is 75 feet. The bridge is nearly completed.

No masonry bridges are in progress, and it is the opinion of some of our best engineers that the age of stone has ended, and that iron has permanently taken its place. No one of our English bridge engineers has yet adopted steel; but this is best explained by the fact that while steel is so much more costly than iron, its great advantage—that of saving weight—is shown chiefly in the case of large spans, and no long span bridges are now in course of construction in England.

American Bridges.—For large bridge works in progress we are to look abroad. In America the widest span of suspension bridge yet achieved—viz, 1,268 feet—has been carried over the Niagara river, almost immediately below the great cataract, and nearly two miles above the railway suspension bridge. The length of suspended platform is 1,240 feet; height above the water, 190 feet; length of part resting directly on cables, 635 feet; height of towers, 100 and 105 feet; base of towers, 28 feet square; width of roadway, 10 feet. The 2 cables are 7 inches diameter each. The weight of the suspended load is 250 tons. The work was designed and carried out by a Canadian engineer, Mr. Samuel Keefer.

Two other great suspension bridges are proposed in America, and it is confidently anticipated that both will be begun and completed. The East River Bridge at New York, projected by Mr. John A. Roebling, is to have a single suspension span of 1,600 feet, and to be in all one mile in length. The height of the roadway is 130 feet; width, 80 feet; height of towers, 263 feet. The Cornwall (railway) bridge is to be carried over the river Hudson, at some distance above New York, in a single span of 1,800 feet; height above water, 155 feet; height of towers above water, 280 feet; total suspended weight, 9,651 tons. The last-named work has been designed by Mr. Julius W. Adams, who has a high reputation in America as a sound and successful engineer, his name alone being sufficient to protect the undertaking in question from any suspicion of its being a mere idle scheme.

Of the iron bridges in progress in America, one over the river Ohio at Louisville, will be one mile in length, and, besides a number of smaller spans, will have 2 of 370 feet each, 6 of 245 feet 6 inches, two of 227 feet, three of 210 feet, &c.* A timber bridge for railway purposes, lately completed over the river Mississippi, at Quincy, has a pivot span upwards of 360 feet long, covering two openings of 180 feet each.

One of the most important works yet commenced in the United States, is the great railway and roadway bridge over the river Mississippi at St. Louis. This work has been fully described and discussed in the last volume of "Engineering." As designed by Capt. Eads, it is to have three arches of steel, the middle arch being of the enormous length of 515 feet.

The iron bridge just completed over the Mississippi at Dubuqe, was built from the designs of J. H. Linville, Esq., President of the Keystone Bridge Co. It consists of 7 spans, 2 of 250 feet, 4 of 225 feet, and 1 of 360 feet resting on the pivot pier, leaving the opening 160 feet

* For particulars see "Engineering," Vol. V., page 506.

wide on each side of the pier. The total length of the bridge is 1,760 feet, or exactly one-third of a mile. The truss is 28 feet high and 16 feet wide in the clear. The lower chord is $31\frac{1}{2}$ feet above low water. The eastern approach is through a tunnel 835 feet long.

Continental Bridges.—On the Continent the finest bridge completed and opened during the year, is Mr. R. M. Ordish's elegant work, the Franz Joseph rigid suspension bridge over the Moldau, at Prague. This is the first practical embodiment of a principle for which Mr. Ordish has contended for so many years, that of straight inclined suspension rods, with a light curved chain to support their own weight in so far as to prevent sagging. This bridge, with a span of 492 feet between centres of towers, a vertical depth between centres of suspension rods of 61 feet 3 inches, and a total length of 820 feet, has been heavily tested with a very moderate deflection, while it possesses also great steadiness under passing loads.

Among the Continental works nearly finished, and soon to be opened, is the magnificent railway bridge in Holland, at Kuilenburg, over the Lek, one of the channels by which the river Rhine reaches the North Sea. Engravings and particulars of this great work are soon to be published in "Engineering." The bridge has one great span of 492 feet, one of 262 feet, and 7 of 187 feet each. The total length is 2,181 feet, and the contract price was £153,000. The girders spanning the great opening are 515 feet long, and 65 feet 6 inches deep.

The railway bridge over the Danube at Vienna will be an important work; comprising 5 spans of lattice girders of 262 feet opening each, and 4 other spans of 112 feet.

The Dutch Government will eventually construct, although they have not yet commenced, the great railway bridge over the main outlet of the Rhine at Moerdyk, between Antwerp and Rotterdam. This bridge will be a mile in length, and it has been proposed to make it in spans of 400 feet each. "Engineering" says :—As compared with such works, there are at present no hopeful schemes in England. Mr. Fowler's proposed great $2\frac{1}{2}$ mile bridge over the Severn, with its 600 feet central span, its 245 feet side spans, its thirty 150 feet spans, its twenty-six 120 feet spans, and its twenty-seven 90 feet spans, is still in abeyance, but it will be built *some time*. It is true we have the frantic Boutet seeking to excite capital for the construction of a 10-span bridge across the English Channel, with openings *only* 3,282 yards (!) in the clear, and it is such schemes, stamped with ignorance, impudence, and infatuation, that sicken the heart and madden the brain of the true engineer.

Harbors and Docks.—A large number of important harbor and dock works were completed last year. The Millwall Docks, by Mr. John Fowler and Mr. William Wilson, comprise 2 basins of 25 acres and $10\frac{1}{2}$ acres respectively, and a graving dock 402 feet long, and 86 feet wide, with an entrance of 65 feet. The graving dock has "bilge carriages," so arranged as to be run under a ship to keep her keel off the ground. These docks have 28 feet of water and 7,700 feet of quay frontage. This work, replete with the latest inventions necessary to afford the most perfect and complete accommodation for vessels, is furnished throughout with the Elswick hydraulic machinery for which Sir William Armstrong & Co. have become famous. A very fine specimen of the telescope bridge is found here, of probably 80 feet span, and which, actuated by water pressure, rises from its bearings and slides endways from off its span, when called on, with incredible facility.

The Sutherland Docks have been extended by Mr. Thomas Meik. The new Hudson basin is 11 acres in extent ; the new outer harbor has been enlarged to 28 acres. The Leith Docks, by Mr. George Robertson, are nearly completed; also the new Western Dock at Hull, by Mr. John Hawkshaw. The Tyne Improvement Works, by Mr. Ure, are progressing. About 4,000,000 tons of material are being dredged yearly, at a cost of rather more than 4d. per ton, and the whole yearly expenditure, including that upon the Great Tyne piers, is about £250,000. A large graving dock* is in course of construction at Hebburn, Gateshead.

The Admiralty works in progress at Chatham, under the direction of Colonel Clarke, will involve an outlay of £1,500,-

* See "Engineering," December.

000, and comprise the reclamation of St. Mary's Island, 300 acres in extent, the construction of 3 basins of respectively 22, 20, and 37 acres, the construction of large graving docks, slips for laying up frigates, etc., and an immense steam factory, 1,000 feet by 700 feet. The new dock in French Creek, Malta, is also progressing under the same direction.

Among proposed harbor works, the improvements at St. Helier's, Greenock, and Scarborough, have attracted the greatest attention among engineers. The Greenock works to be carried out, comprise a large basin, graving dock, extensive quays and warehouses, and special arrangements for shipping large quantities of coal. At Scarborough, the only work proposed is a pier, enclosing on one side a harbor larger and better than at present.

The Clyde Trustees have decided upon the construction of a graving dock of great size, viz., 503 feet long, 100 feet wide, and 30 feet deep, the entrance to be 83 feet wide. New harbor works are to be at once commenced at Aberdeen, and additional works are proposed at Dublin, at Newport, Cardiff, Llanelly, and at Porthcawl.

A new graving dock is building at Williamstown, Victoria. Its dimensions are to be 240 feet by 97 feet, with an entrance 80 feet wide.

Mr. Hawkshaw is constructing the Grand Canal to connect Amsterdam direct with the North Sea, so that ships from the Dutch capital will strike deep water a little to the north-west of Harlem, instead of beating miles out of their way around the Helder.

Nor should the works in progress at Havre be forgotten. The seven basins, as fine in their way as anything in Europe, are to be still further extended, and Messrs. I. C. Johnson & Co., of Gateshead-on-Tyne, have a contract with the French Government for 20,000 tons of Portland cement for these very works.

The Bermuda Floating Dock.—During the year a great iron floating dock, capable not only of taking the largest ship in the navy, but of careening her as well, has been completed for Bermuda. This structure is 381 feet long, 124 feet wide, 72 feet deep, and weighs 9,000 tons.* This is a double dock, one within the other, the sides or "double skins" being 20 feet apart, and enclosing respectively a load chamber, balance chamber, and air chamber. Water may be pumped into or from either of these chambers, so as to sink, lift, or tilt the dock as desired. This great work, designed by Colonel Clarke, of the Admiralty, was constructed and, after a slight hitch, successfully launched by Messrs. Campbell, Johnstone & Co., of North Woolwich.

The hydraulic graving dock, of which the first example was erected ten years ago at the Victoria Docks, is having new innings. One has just been sent out to Bombay. It has 36 hydraulic presses in all, each of a force of 400 tons, so that the total lifting power is 14,400 tons, and including its "saucer" it will thus lift the heaviest ship in the navy. Docks upon the same plan are spoken of for Jamaica, Malta, Brindisi, and Dundee.

The Holyhead Pier.—At Holyhead the great breakwater pier approaching completion, under Mr. Hawkshaw's auspices, is a noble specimen of marine engineering. It is constructed chiefly of stone taken from the mountain adjacent. The upper structure is of random-worked ashlar, presenting a flush face on the inside or harbor front, while on the sea face the material is quarry-faced, and, as far as may be practicable, set on end, giving it the appearance of being vertically ribbed. The base of the pier consists of *pierre perdue*, having a slope, of the angle of repose of the material, on the inside, while on the outside its form is that of a flat glacis, on which the sea must lash with intense fury, as the stone is much pulverized by its action, especially so in the gorge caused by the re-entering angle of the work. The plan of the work is that of a continuous wall, of 1½ mile long, zigzag, with 2 kants springing from the land at one end, and at the other resting in 13 fathoms of water at low tide. The upper structure carries a causeway of 38 feet wide, at 12 feet above which, on the seaside, there lies a banquette of 15 feet wide, floored with tooled limestone, and surmounted by a parapet of 4 feet high, of the same material and class of workmanship; which latter throughout appears to be as near perfection as possible. The high level is connected with the causeway by flights of stairs at intervals. From the base of the parapet on the external face

* See "Engineering," Oct. 19, 1866.

projects an echinus of 2 feet overhang, which, however it may add to the effect of the sectional profile, will surely meet with rough usage from the waves towards the extremity of the pier. Here green water of yards thickness comes over the parapet during a gale. The pier head is not yet completed. It will be, in plan, of a T section, the arms of the T showing a very slight projection, and rounded at the ends. The face-work here will be of granite blocks, of from 8 to 12 tons weight each; the hearting of red sandstone, of the same dimensions.

Port Saïd Harbor.—Extensive harbor works are, it is understood, to be undertaken, by an English company, at Alexandria. The works are to comprise a breakwater 3,250 feet long, a mole 1,650 feet long and 200 feet wide, 5,000 feet of quays, and a large dry dock. To the east of Alexandria is the new harbor of Port Saïd, at the northern end of the Suez Canal, the later now more than two-thirds finished. Port Saïd, now nearly completed, is formed by two piers, one 2,730 yards and the other 2,077 yards long, with an opening to the north-east. The harbor enclosed is nearly one square mile in extent, and the western pier is carried out into water 27 feet 6 inches deep. These piers have been formed of *béton* blocks, of which about 325,000 cubic yards only have been used. At the present rate of progress the canal itself will be finished in little more than a year, with a waterway 328 feet wide and 26 feet deep.* Apropos of harbor works on the Mediterranean, it may be added that there is a scheme to greatly extend the port of Marseilles. A paper, read some time since at the Institution of Civil Engineers, gave a most interesting account of the existing works there, which comprise, among other things, the loftiest and possibly the finest warehouses in Europe, unless we except the magnificent corn warehouses lately completed at Liverpool and at Birkenhead.

Growth of Philadelphia.—During 11 months in 1868, there were erected in Philadelphia 4,706 new buildings, and 1,173 buildings received alterations and additions. This city now contains above 800,000 inhabitants.

* See article on the Suez Canal on another page.

Protection of Large Buildings from Lightning.—This subject has been reported upon by M. Pouillet before the Paris Academy of Sciences. The "Engineer" gives a lengthened account of it. The first thing to be done is to establish a conductor, formed of square iron measuring four-fifths of an inch on the side, which shall pass without interruption over every portion of the building to be protected ; when the line is broken by towers, pavilions, or other erections, the conductor must pass up and down each, so as not to interrupt its course. This main conductor, of course, is modelled, as it were, to the form of the building, and often consists of several branches, particularly in the case of edifices like the Louvre, where there are several blocks of buildings perpendicular and parallel to each other ; it will also have many minor branches, for it must be placed in good communication with all the gutters, leads, and other large metallic surfaces on the roof. This great conductor or circuit must be placed in direct communication with a body of water, which is never wanting. Ten or a dozen wells might be dug to receive each a conductor leading from the main circuit. Each lightning-rod must be placed in perfect communication with the main circuit.

Cement to Resist Red Heat and Boiling Water.—To 4 or 5 parts of clay thoroughly dried and pulverized, add 2 parts of fine iron filings free from oxide, 1 part of peroxide of manganese, one-half of sea-salt, and one-half of borax. Mingle thoroughly, and render as fine as possible, then reduce to a thick paste with the necessary quantity of water, mixing thoroughly well. It must be used immediately. After application it should be exposed to warmth, gradually increasing almost to white heat. This cement is very hard, and presents complete resistance alike to red heat and boiling water.

Another Cement.—To equal parts of sifted peroxide of manganese and well pulverized zinc white, add a sufficient quantity of commercial soluble glass to form a thin paste. This mixture, when used immediately, forms a cement quite equal in hardness and resistance to that obtained by the first method.—*Blätter für Gewerbe.*

PUBLIC BUILDINGS.

HOSPITALS—THEIR REQUIREMENTS, ARRANGEMENT, AND VENTILATION.

Condensed from a paper before the Architectural Association by T. R. Smith, F. R. I. B. A., and from the ensuing discussion.

Hospitals are peculiarly a modern institution. While examples of many classes of structures suited to our modern ways, such as, for instance, houses, baths, theatres, and churches, abound in the remains of classic times, there are no Greek and Roman hospitals. The simple infirmary of a monastery is no example to us as to *scale;* and the vast establishments of the 16th and 17th centuries are not very valuable specimens of arrangement and detail.

When we remember the great cost and disturbance of domestic arrangements necessary to provide suitable air, light, quiet, medicine, food, and attendance to the sick in our houses, and reflect that the poor, and even the majority of the people, cannot provide nor afford these facilities, the necessity for *many* hospitals and of *good* hospitals with all these facilities that make the difference between life and death to so many of our fellow-creatures, becomes obvious.*

At the same time, so good an opportunity of studying disease is not to be neglected. Where some hundreds of sick are always collected, there the students of sickness and how to cure it ought to be, and in fact are found.

What a Hospital Must Provide for.—We have now the elements for understanding this question.

First. The inmates, or in-patients, that is, the sick who reside and are treated in the house. The rooms they live in are technically termed wards.

Secondly. The administration. This embraces medical officers, dressers, sisters, nurses, attendants, and the parts of the building appropriated to their use, and to cooking, stores, business offices, etc.

Thirdly. Out-patients. Those who come to the hospital periodically for advice and medicine, and the portions of the building where they are received, seen, and supplied.

Fourthly. The Medical School, that is, students and professors, and their lecture rooms, library, museum, dissecting room, etc., etc.

Requirements of Wards.—The most important part of a hospital is the wards. For economy of attendance it is practically found best to place from 20 to 30 beds in a ward; reserving, however, a few small wards where only 2 or 3 beds are receivable for special cases.

The most important provision for the sick which the architect can make in a hospital, is a supply of plenty of fresh air. This is the one consideration to which all others ought to give way. The patient ought to have plenty of air in his ward, and that air ought to be constantly renewed. This, according to all authorities, will promote his recovery more than any one thing, and will prevent his injuring his fellow-sufferers. Many diseases are directly communicable by atmosphere, and surgical cases vitiate the air of the room. The best authorities consider that each bed should have from 1,500 to 2,000 cubic feet of air space, and that the change of air, while, of course, not sufficiently rapid to create a draft or a breeze, should yet be sufficient to be felt as an air passing over the face and hands. The sick must not be so placed that the air to reach any bed must necessarily pass over any other, they must not be too many in one room; there must not be too many wards under one roof, nor too many stories of sick one above another, nor too ready access from one ward to another. And there must be clear passages between the beds and up and down the ward.

Next to air, light and cheerfulness are conducive to health. All these requirements are practically best met by wards that are long in proportion to their width, arranged so that one of the long sides shall have an aspect exactly or nearly south, with a row of beds at each side, placed with their heads to the wall, and a row of windows on each side. A width of over 20 feet, and under 30, averaging 25 feet, is the most useful; over 30 feet the ventilation becomes sluggish. Beds ought to be about 8 feet apart from centre to centre, and the height of the ward ought to be at least 15 feet. No bed should come in front of a window. A window to each 2 beds is the usual allowance, and the windows ought to go as

* Even in the large English schools it has been determined to make the hospitals in one ward, rather than in separate rooms.

nearly as possible to the ceiling, and to come down low enough for patients in bed to be able to look out of them.

VENTILATION is a subject upon which authorities in all countries differ. The best known and most followed English plan is having windows facing each other on the two sides of each ward, and keeping them almost constantly open. This is termed natural ventilation. For this purpose windows may be sash windows in several heights; often, however, they have in their height several casements, each hung at the bottom edge, and capable of opening back at the top, so that the incoming air shall be thrown upwards. These casements ought to be capable of being regulated with great nicety, and made to remain at whatever angle they are set. They should be glazed with thick plate glass to diminish the loss of heat that occurs at all window openings; or, better still, double glass, with perforated zinc, taking the place of some of the panes of glass.

But there is in this apparatus the means of killing patients as well as curing them; especially in a climate like ours. Window ventilation, especially where not tempered by wire gauze or perforated zinc, is often the cause of fatal or dangerous relapses. Patients suffering from kidney disease, bronchitis, or rheumatic fever, are certain to relapse if they get a chill. A greater degree of care is required where there are many surgical cases. The belief is therefore spreading, that an appliance for keeping up a supply of fresh air, warmed and moistened, and for drawing off foul air, ought to form part of a hospital ward, and ought to be equal to keeping the wards thoroughly aired in frosty or stormy weather, at night, or at any other time, when windows cannot be safely open.

In the warming and ventilation of the new St. Thomas's Hospital, in each ward there will be 3 open fire-places on the centre of the floor,* with a vertical tubular flue from each passing up to the ceiling, having an outer air-tube round. This will serve to carry off some of the vitiated air beyond what goes up the flue with the smoke. The architect has also supplied 4 foul air extraction flues, which meet in the roofs, and near the outlet of which a current is kept up by a coil of hot-water pipes, which will be always at work, as they are part of the system for supplying hot water night and day to each ward. As an auxiliary for cold weather, coils are introduced on the floor, and the boiler for working them is a separate one. Air inlets exist in the floor. These arrangements are quite distinct and disconnected for the different pavilions as though they were distinct buildings.

There are hospitals with ward windows at the ends only, or merely along one side, and one row of beds down the centre, or even double rows with an open arcade between them like the nave and aisle of a church. But the knowledge has been slowly and painfully obtained, that these forms of wards are all, for this climate at least, a mistake, for the reason solely that they are found more difficult to ventilate, and there seems no reason to believe that any material alteration will be made in the dimensions, proportions, or arrangement of a hospital ward, till we have first established, if ever it can be done, a perfect system of hospital ventilation.

PROVISION AGAINST INFECTION.—The ward ought to be so fitted and finished as to harbor neither vermin nor infection. Wall paper and wooden skirtings must be dispensed with. Ordinary plaster is porous, so is soft wood; common floors and walls are therefore liable to absorb insidious poisons. The floors, accordingly, ought to be of the hardest wood, such as oak, not tile, which is chilly to the feet, and ought then to be rubbed with beeswax and oil till all the pores are filled up, and the surface is smooth and hard, or else oiled and lacquered, as is the fashion in Berlin. The walls and ceilings ought to be of the hardest obtainable material, Parian cement being recommended as having the best surface for the purpose.

HEATING.—For the heating of hospital wards, English authorities concur in recommending open fires. The French frequently warm their hospitals as they do other public buildings, by a hot-air apparatus, and must thereby run a risk of diminishing the advantage of their excellent arrangements in other respects.

THE BUILDINGS ATTACHED TO THE WARD

* To prevent these fires from heating the nearest beds too much, the openings to the fire-places are made to look up and down the hall or ward.

should be as follows: The head nurse of each large ward requires a separate room with a window looking into the ward. A smaller room called a ward scullery is also required with a fire-place, hot and cold water, and a sink. At the opposite extremity of the ward are required a group of closets, and one or more baths, and a lavatory. The arrangement of the closets is most important; not only should each have direct ventilation, but there should be a cross-current of air traversing the passage between the ward and the closets, in order, if possible, to prevent effluvium from coming into the ward. There ought not to be fewer closets than 1 to every 10 patients. Somewhere near the ward, but not in it, there ought to be a small lift, on which the patient's food, technically termed the diets, is brought up from the kitchen corridor, and it is usual to provide both a dust shaft and a foul linen shaft, from outside each ward to the basement. A large lift, capable of taking a patient and his bed and an attendant, ought also to be provided in each block of wards.

These, and no other rooms, ought to be appended to each ward. Convalescent rooms where they are introduced ought to be elsewhere.

The Series of Wards.—How are they to be arranged so as to make one large institution? From considerations of economy, especially in cities, we place them one above another; but this soon reaches a limit, and is objected to entirely by Miss Nightingale and others It is agreed on all hands, that it is advisable not to put the sick into a story exactly on the level of the ground floor.

The modes in which wards have been arranged are very various, but there appears to be a general feeling that the best possible way has been now found out. Where only two wards on a floor constitute the hospital they are well arranged in a continuous line with a staircase in the middle; where a larger number of wards has to be provided on each story, they would now be arranged parallel to each other (so that all can have a sunny aspect), and at a very considerable distance apart. This is called the pavilion plan, or block system. Each pavilion is in fact the ward, with its appendages repeated as many times as there are to be stories, and has its own independent staircase. It is isolated from its neighbors by a space which ought to be enough to keep it almost all day clear of the shadow of adjoining pavilions, affording its windows all the air and sun they require, and it is connected to its fellows by a corridor on the lowest story only. A usual plan is to make these pavilions occupy two sides of a hollow square. The best known example is one of the Paris Hospitals, the Lariboisière.*

Other Departments and Buildings.—The principal entrance for in-patients, leading to a receiving room, should be well marked and readily accessible.

The out-patients require a simple but spacious and well-ventilated waiting room, with a separate entrance and vestibule. The adjoining physicians' and surgeons' rooms should also adjoin each other, and should have a good light. A dispensary for receiving prescriptions and issuing medicines through a window should be convenient to the waiting room. All these rooms should have closets. A casualty ward where persons not seriously injured may be attended to, should form a part of this department.

An operating room (a theatre in large hospitals) should be accessible to the various wards. It should have a northerly top light, and connect with a surgeon's room, and a small ward for patients who cannot at once be removed after operations.

The dissecting room should be lighted from the top, and specially well ventilated. It should adjoin a dead-house.

Rooms for the physicians and surgeons, and residences for other officers and attendants, should communicate with a corridor leading directly to the interior of the hospital. The number of personal attendants on the sick is, in the best hospitals, one to every seven or eight patients.

The kitchen should be removed from immediate contact with the wards and ordinary entrances, and yet should be accessible to marketmen and tradesmen. It should be surrounded by the necessary stores and offices, and should have a wine cellar and ice-house. At the same time it must be central, so that the "diets"

* This, and several of the best modern hospitals, are illustrated in the "Civil Engineer and Architect's Journal," May, 1863.

(cooked rations) may be quickly carried to the various wards by lifts.

Linen, bedding, and bandages require a separate department. So does the laundry.

In arranging these separate departments, one rule should especially be followed—that whatever goes into them should pass in a direct course from one end to the other, without being shifted back and forth.

A Medical School, in addition to bedside or clinical lectures, should usually be attached to large hospitals, and should consist of lecture rooms, rooms for experiments and preparations, professors' rooms, a library, and a museum.

Sites.—As to sites for hospitals, Miss Nightingale says unhesitatingly that they ought all to be in the country. Certain it is that a pure air and plenty of space are the most important of all conditions of recovery. The arguments against the country are—first, that such sites are out of reach of patients; secondly, that they are out of reach of doctors; and lastly, that they are out of reach of students. The site must be spacious, airy, dry, sunny. It should not if possible be in an overcrowded neighborhood, or with any nuisance near. A gravelly soil is preferable, and a sufficiently high elevation. A bed of concrete over the whole site is recommended as a good preventive against moisture; this has been done at St. Thomas's.

NEW SYSTEM OF SCIENTIFIC EDUCATION.

A new system of high scientific education has been adopted in the government schools of France. The following abstract of the system is from the Paris correspondence of the "Engineer":

The new scheme, which is founded on Imperial decrees only a very few weeks old, includes not only laboratories of education and of research, but also the creation of a practical high school or college of science (*Ecole Pratique de Hautes Etudes*). The main idea of the plan is bold, simple, and sensible, namely, the making the present educational staff and establishments available for the new institution. With the view to carry it out, the Government has introduced into its budget an augmentation of the salaries of professors in the superior schools and colleges, to come into operation from the year 1869, in recompense for the additional labor which will be demanded of them in giving class lectures in addition to their present public ones.

The new laboratories will be of two kinds, one for instruction the other for research, the former being as it were nurseries for, and supplying the professors with assistants for the latter. Such laboratories of research, of which three or four already exist in Paris, have, says the Minister, "enabled Germany to arrive at that great development of experimental science which we watch with so much uneasy sympathy."

The new school is not to be essentially a professional school, but a college for improvement. "The young man," says the report, "who feels within him the sacred flame at which, perhaps, genius may light its torch; he who has completed his general studies, or the spirit of which may be repugnant to him; he who is not tempted by the hopes of a lucrative calling, or who may be irresistibly attracted from a profession already acquired towards pure science, does not find in our present establishments all the means necessary to help him rapidly and surely to the object of his vocation." Besides books, collections, and general lectures, he wants precise directions, general council, or support, and the means of verifying by observation and experiment the facts which he has acquired. "Able professors," says the report, "often discover peculiar bents or capacities in their pupils, and in the case of chemistry during the last thirty years much has been done in the way of superior education, and the rank of France in the world of science has greatly benefited thereby. The object now is to supply the other branches of science with schools like that which has done so much for this science." The word "practical" must not be taken in its ordinary signification of industrial utility, but in the higher sense and as indicating that the eyes and hands require to be called into use to strengthen and extend the most delicate and highest conceptions of the scientific spirit. What are chemistry without manipulations, physics and physiology without experiments, or botany without herballising?"

The school is to be divided into four

sections, entitled:—Mathematics, physics and chemistry; natural history and physiology; and historical and philological science; and to these may be added hereafter a section for juridical studies. Of course a pupil may belong to all or several of the sections.

The school is open to all the world, without any limit as regards age, grade, or nationality, but all pupils must undergo a preliminary stage of three months or less, at the termination of which the director makes a report; they are then examined by a permanent commission which sends up a list to the Minister, with whom alone rests their nomination to the school. Pupils can only remain 3 years on the school list. All the private lectures and normal lessons of the professors are open to them as well as the laboratories of instruction; they are bound to furnish written essays, *précis*, and analyses on given subjects and works published in France or abroad, and to make researches in the libraries and museums on set subjects, and to report results in writing; and the pupils in the natural history section will take part in scientific excursions under the direction of the professors. No mention is made of fees, so that the education appears to be perfectly gratis; and moreover the Minister may, upon the recommendation of the superior council, allow an annual indemnity to the pupils of the school. The directors of the laboratories have also the power of recommending pupils who show great aptitude as their assistants, and the Minister has the power of awarding them indemnities. Each section of the school is placed under a commission of five members nominated for three years by the Minister of Public Instruction, and chosen by him from the list of directors of laboratories and studies, as the professors of the school are called. The directors of the laboratories and of studies will grant certificates to their pupils, and make annual reports to the commission, and after examination of these reports by the superior council the Minister will entrust successful pupils with missions and award medals, honorable mentions, subventions, or special recompenses.

The organization of the new school extends to the provinces, the directors of laboratories and studies connected with scientific establishments in the departments as well as the pupils to enjoy the same privileges as those of Paris.

LIQUIDS FOR HARDENING STEEL—TEMPERING COLORS.

From a new Treatise on Steel, translated from the French of M. H. C. Laudrin Jr., by A. A. Fesquet. Philadelphia, Henry Carey Baird, 1867.

Notwithstanding what has been said, and the so-called experience of some practical metallurgists, pure water is the best liquid for hardening steel. It is a mistake to believe, with the ancients, that certain waters are more adapted to this operation than others. The only difference lies in their temperature. A workman of Caen, M. Damesme, who has published a diffuse work on steel, has tried the hardening of steel in the juices of vegetables, and has ascertained that there is comparatively no advantage over hardening in water. Mercury has no other property than that of being cold, and of producing a hardness which can be obtained with water at the same temperature.

Tallow and oils, where carbon is one of the constituent elements, produce an imperfect hardening, but prevent a loss of carbon. When by overheating, steel has been burned and decarburized, the oils and fatty matters are useful, because they give back to the steel a part of the carbon lost in the fire. Some acids, such as sulphuric, are justly considered as imparting more hardness to steel, by dissolving a film of iron from the surface and exposing the carbon. As for urine, alcohol, brandy, and a thousand other liquids extolled by ignorant workmen, they are not worth as much as water, which has the advantage of being abundant everywhere, cheap, and adapted to all changes of temperature.

Some workmen heat the steel which is to be hardened, much above a cherry redness, allow it to cool slowly in the air, and wait until it has taken a certain color, previous to plunging it in water. This is a very bad practice, because by an excess of heat there is a loss of carbon, and an alteration of the steel, which has then large grains, and is without tenacity at the edges.

After hardening, the temper or hardness is drawn as required for different purposes by reheating—the color of the steel being the guide.

1. Being put upon burning fuel, the steel gradually heated becomes tarnished, yellow, and *straw yellow.*

2. The heat increasing, the color deepens, and reaches a gold yellow, *full yellow.*

3. Afterwards, the steel takes several shades, rapidly following and blending with each other ; they are purple, pigeon's throat, copper, *brown purple.*

4. These shades become deeper until they become *violet.*

5. Afterwards, they pass rapidly to indigo blue, *full blue*, *dark blue.*

6. This color becomes weaker, and gives a *sky blue* more or less pure.

7. The blue takes a greenish tint and produces shades which are gray and *sea-green.*

8. At last, the steel *reddens*, and will no longer give distinct colors.

The shades of these eight colors, which are called tempering colors, and perfectly distinct, very apparent, and easy to recognize; but they take place only after hardening and on clean steal. The metal which has not been hardened, will not show these colors so plainly ; the shades are mingled, blended, and less in number.

The colors, during the tempering, are a sure guide for the workman, of the degree of hardness or tenacity he desires to obtain. Dark blue indicates a great tenacity, straw yellow produces a greater hardness, and is the tempering shade for razors. Bistouries, lancets, penknives, erasing knives, some scissors, and generally blades requiring body, are reheated to full yellow. The strong blades for table knives and gardening tools are tempered to a brown or purple brown. Purple is the proper color for large shears. Violet and dark blue are for springs ; with a violet color, the spring will be very elastic but brittle, a blue shade will make it very resisting. It is very difficult to break a spring reheated to the color of water; but its elasticity is a great deal lessened.

The hardened instruments are reheated in or upon a live fire, easily regulated, and without the help of bellows as far as practicable. An intelligent workman will cease blowing as soon as he perceives that the metal begins to change its color. The proper shade must come by itself without increasing the fire, and must be regular all over, before the piece is plunged in cold water. Sometimes this last dipping is omitted.

The small pieces, such as penknives, erasing knives, etc., rest upon a wire cloth put into the middle of the fire; when they have reached the proper color they are cooled in water.

A lancet requires a special tempering; the shank must be blue; from there the color will be first purple, next brown, and at the point, full yellow. These various shades upon one blade are a necessity, on account of the degree of hardness and tenacity required by this instrument. Full yellow will produce the proper sharpness, but would not be suitable to the rest of the blade, which, instead of hardness, must have tenacity and elasticity.

A good workman, willing to give the greatest perfection to an instrument, will be very careful when tempering it, in order to obtain the various shades which are necessary. A knife, for instance, must be brown purple at the cutting edge, purple in the middle, and sea green at the back, to unite the hardness of the cutting edge, with a certain amount of resistance which will prevent its breaking under a strain.

This is obtained by using certain precautions, and above all, by not going beyond the proper degree, because it is very difficult to retrace the steps. If the fire was too strong or irregular, part of the edge may be purple brown, while the other is only straw yellow; then, by pinching the blade between red-hot tongues, at the place which should be more heated, the temperature rises rapidly, and the instrument is brought up to the proper tempering point. Certain scraping and burnishing tools, and steels for sharpening, do not require any tempering, because they cannot be too hard.

The Rhode Island Locomotive Works are making 5 locomotives a month, and their capacity is to be doubled.

Lead Pencils, once really made of lead, are now chiefly made of the plumbago from the Alibert mines in Siberia.

ELECTRIC LIGHTS FOR LIGHT-HOUSES AND SHIPS.

By Ernest Saint Edme, of the Conservatory of Arts and Trades.

Translated from *Annales du Génie Civil*, September, 1868.

The Electric Light is nothing but the luminous arc formed between two carbon points fixed at the poles of a strong pile, or magneto-electric machine. It is due not to the combustion of the carbon points, but to the irradiation of their molecules, which fly continuously from the positive to the negative pole of the source of electricity. Hence, were there no combustion, that is, were the operation in a vacuum, the distance between the points being regulated according to the intensity of the current, there would be a continuous luminous arc, since the exact quantity of matter forming from the positive would arrive at the negative pole.

The function of a *regulator* of the electric light is, therefore, to correct mechanically the space between the carbon points, which results from their combustion, in air. The operation cannot be in a vacuum, for the glass envelopes cannot resist the heat due to the formation of the arc. Messieurs Staite and Petrie in England, and Léon Foucault in France, solved at the same time the question of photo-electric regulators; and to Foucault is due the first idea to make the electric current itself regulate the movement of the points. Since the first attempts to apply magneto-electric machines to produce light, the regulators exclusively used were the well-known ones of J. Dubosc, disposed to utilize the continuous currents; but the conditions of the apparatus were such that they could work with intermittent currents. A little later, when the regulator of Mons. Serren was coming into use, Mons. Joseph von Malderen, during a discussion, inquired of him whether he could overcome some of the defects of Dubosc's lamp; and he found that the principle of Serren's regulator was such that it could work with currents uncorrected. Thus it was a lucky chance that led to the discovery that the regulator of Serren, constructed like all others to be used with currents from the pile, could work with the uncorrected currents of the machines; but that which had no chance about it was the intelligence and perseverance of Malderen, who comprehended that the difficulty came from the regulator; and that what one failed in, the other might perhaps accomplish.

Since then, each inventor had to transform his apparatus; and Foucault, just before his death in 1866, gave the last touch to one of his early models, and confided to Dubosc the task of realizing his idea. Serren's regulator was applied in the light-house at Cape la Hève, and Foucault's in the garden of the Exhibition. The latter excited doubts on account of the great precision required in fitting; but a trial of long duration proved the genius of its author, and his ability to reconcile delicacy and complexity with solidity.

Foucault undertook to make a regulator that should absolutely fulfil the two main conditions—the diminution of all the causes of extinguishment, and the fixity of the luminous point. The two principal causes of extinguishment are: the too great separation of the carbon points, and their accidental contact.

[The description of the apparatus would be scarcely intelligible without the engravings, which we have not time to prepare for this number; we therefore must refer those who are specially interested in the details to the *Annales du Génie Civil*, for September, 1868.]

This regulator, constructed by Dubosc, has since been arranged by him to work either with the pile or the magneto-electric machine, with the precision required; and it is sufficiently hardy for service in light-houses, ships, and operations under deep water.

Mons. Reynaud, director of the administration of light-houses, three years ago, made a complete report on the question of electric lighting on the coasts; and since then nothing of interest has appeared to add to that report. The following tables taken from it show that the cost of lighting by oil is dearer than by electricity, in the proportion of 580 to 79.

Light-house with Oil Light.

	Francs.
Apparatus, with armature	37,940
Mechanical lamps, 3	2,100
Revolving machine	3,200
Furniture	900
Lantern, with glass, etc.	20,400
Setting up	3,900
	68,440

Annual cost for 4,000 hours of lighting.

	Francs.
Interest and wear, 10 per cent	6,844
Annual expenses	7,973
	14,817

Which, divided by 4,000, gives 3.7 as the cost per hour.

The intensity of the light sent to the horizon, is about equal to 630 Carcel burners: the cost per unit of light equal to that of a Carcel burner, is therefore .58 francs.

Light-house with Electric Light.

	Francs.
2 magneto-electric machines	16,000
2 steam engines and accessories	6,000
2 regulators and setting up	3,000
Lenticular apparatus	3,000
	28,000

Cost per hour for 4,000 hours per year.

	Francs.
Interest and wear	.70
Fuel for steam engines	.40
Wages for 2 firemen	.70
Wages for 2 watchmen	.50
Carbon crayons	.36
Oil, etc., for machinery	.13
	2.79

The mean intensity of the light sent towards the horizon, that is, taken outside of the apparatus, is equal to 3,500 Carcel burners, which gives as the cost of a Carcel unit of light sent to the horizon, $\frac{2.79}{3500}=$ .079 francs.

Against this immense advantage in favor of electric light there is the fact that the light from oil has more power to penetrate fog, being richer in red rays, than the electric light. In misty evenings one can see that the moon and gas lights have a red or orange tint, the blue rays being refracted, and unable to traverse the foggy atmosphere. Therefore, to make the electric lighting sure, it is necessary to have 2 machines, one of which will be kept ready for use in case of accident to the other; or in case of fog, when both will work together, and give double light. In this way the greater atmospheric resistance is overcome. This expedient is not possible with oil lamps; for we cannot double the flame of a lamp as we can double the electric current that flows between the carbon points.

Electric lighting in light-houses seems not to have made much progress since the report Mons. Reynaud; and the reasons of it are easy to be seen.

To transform existing light-houses, we must sacrifice the existing apparatus, for the sole advantage of increasing the light at any moment. Besides, it is doubtful whether all light-houses are large and strong enough for the accommodation of the new machinery; this is certainly the case with most of the light-houses on the coast. As to the light-houses of inferior order, it would be illusory to think of altering them. And other difficulties are inherent in electric lamps, which, however well designed, are subject to causes of derangement which render necessary the best mechanism; and the crayons, if impure, may scale, and cause interruptions; and these impurities might cause mistakes incompatible with the service of the light-house.

In conclusion, when a new light-house is to be built, it will be advantageous to adopt the electric light; but the importance of the question, relative to the general administration of light-houses, is much less than was at first supposed.

In 1863, in a notice of the applications of the electric light, we suggested the lighting of vessels by it. The maritime exhibition at Havre shows that our suggestion has been considered, at least in principle. In the point of view of lighting the course of a ship, no one will deny that the oil lantern is insufficient to prevent collisions at night; while the electric lantern would illumine the air all around, and the rocking of the vessel would cause such changes of light as would attract the notice of the men on other vessels. When we consider the whole cost of a ship, that of electric engines is insignificant; 2 or 3 horse-power will work a magneto-electric machine. And the electric light will serve other purposes on board a ship. Recent experiments have shown that it would be possible to assist a ship in her course by dazzling the steersman by a jet of light, when an oil lantern would not be seen by him.

It can also be used to light under water; an application that concerns the repairs of the sheathing and hulls of vessels, the finding of lost articles, and the catching of fish. The fish are confused by the light, and then easily caught. Mons. Dubosc exhibits a specimen lantern well fitted to enclose an electric lamp. The conducting wires are connected so that there is no chance for water to leak into the lantern. This apparatus can, without fear of too high pressure, be lowered to great depth in the sea.

View from a Balloon.—The view over London, in ascending 2,000 feet, is thus described by the "London News":—The earth and its dwelling-places, its trees, its roads, its rivers, drop slowly down and resolve themselves into a clearly defined, widely spreading map. The steamers plying on the Thames recalled the toy-boats at the Polytechnic; the black ants rushing busily to and fro in the barren space immediately below were schoolboys in a playground a few minutes since; the strips of drab tape stretching their devious courses to right and left are roads; the squares and oblong green patches with dark borders, fields; and that large table upon which a game of dominoes is apparently being played is Brompton Cemetery; and it is its profusion of white tombstones, some flat, some upright, which are recalling the old game. There seems a mighty stir among the pigmies below, and huzzahs which become faint in the distance, but are never quite lost, come up to us cheerily. The small boxes drawn by ants, into which cabs and omnibuses have resolved themselves, twine their way along the strips of drab tape, and almost arouse wonder by never deviating from their path.

Sulphocyanide of Ammonium. — At the last meeting of the British Association, Dr. Phipson read a paper on this subject, in which he pointed out a fact of some importance to agriculturists, viz.: that for many years past the ordinary sulphate of ammonia manufactured in gas works by neutralizing gas liquor with sulphuric acid contained small quantities of sulphocyanide of ammonium, say from 2 per cent. to 4 per cent. ; but latterly many specimens of commercial sulphate of ammonia contained a very much larger proportion, some specimens yielding as much as even 75 per cent. of sulphocyanide. So that, in fact, the article might rather be named impure sulphocyanide of ammonium than sulphate of ammonia. The knowledge of this fact is of great importance to makers of chemical manures and farmers, inasmuch as only one-half of the nitrogen existing in sulphocyanide can be made available for manuring purposes.

Chemical Nature of Cast-Iron. — At the last meeting of the British Association the report on this subject by Dr. Matthiessen and Dr. Russell led to some discussion. It seems that though no less than 70 experiments were made in the production of pure metallic iron from its various compounds, the reporters had not yet succeeded in obtaining any iron perfectly free from sulphur. Dr. Mathiessen hoped, however, by continuing his researches, yet to obtain a perfectly pure sample of metallic iron. In the course of the discussion which followed, Mr. Sutton suggested that probably the presence of sulphur in iron was only another instance of the persistence of that element in the atmosphere, as shown by the experiments of Mr. W. F. Barrett, who first devised the method of detecting the presence of sulphur upon the surfaces of bodies exposed to the air by projecting upon them a flame of hydrogen, a magnificent blue flame resulting therefrom.

Boiler Explosions, having been attributed, from time to time, to every known agency of explosions, it is not singular that upon the discovery of nitro-glycerine, they should have been attributed to it—upon the following curious reasoning: Fatty matter in the water in a boiler, acts chemically on the steam, forming glycerine. When organic matter is present in the water, the chemical affinities will set free electricity, which generates ammonia—which mixed with moist air at a temperature 212° Fah. over water containing potash, produces the nitrate of potash. Glycerine and nitric acid readily combine chemically, the glycerine gives up a portion of its hydrogen and takes on a part of the oxygen, when they all combine into a new compound, nitro-glycerine, which has $2\frac{1}{2}$ times the specific gravity of water. Nobel's blasting oil is composed of glycerine, sulphuric acid, and the nitrate of potash. Nitro-glycerine being insoluble in water, and having greater specific gravity, it readily finds the bottom of the boiler, where it would remain were it not for the sudden rise of temperature. It is not explosive at 212° Fah., but at 360° Fah. (which it soon attains in contact with the boiler plate), explodes with 13 times the force of gunpowder. Hence those terrific and unaccountable explosions that so often take place when the boiler contains its maximum of water. Finally, at least 90 per cent. of all the terrific disasters on our western rivers have occurred in the spring of the year, when the rivers were full of surface water containing organic matter, fats or oils, potash, and sulphur; or they blew up at or near the levee of some city, where they had taken on a supply of water contaminated with sewerage, containing the very elements of destruction.

As the *Scientific American* suggests, all the elements of gunpowder also exist in river water, and gunpowder is, therefore, as likely a cause of boiler explosions as nitro-glycerine.

AN ENGLISH EXPRESS LOCOMOTIVE.

The following are the principal dimensions of the latest style of passenger engine on the Great Northern Railway. The engine has a pair of leading and a pair of trailing wheels, a pair of drivers nearly in the centre, and inside cylinders —the old-fashioned English engine, without modern improvements in the distribution of weight and strain, but well-proportioned in detail:

	Ft.	in.
Boiler:		
Diameter of barrel, inside smallest plate..	3	9½
" " " largest " .	3	11½
Length of barrel	10	2
Length of inside firebox	4	8¾
Width " "	3	5
Height " " at front	5	9¼
" " " at back	5	3¼
Thickness of barrel	0	0½
Thickness of smokebox tube plate	0	0¾
Thickness of firebox plates ½ in., except tube plates, which is ⅞ in. thick at the upper part, and thinned to ½ in. below the tubes.		
Number of tubes, 192.		
Length " between tube-plates	10	5⅞
Diameter " outside	0	1¾
Thickness " at firebox end No. 12 W.G.		
" " " " " 14 "		
Length of smokebox inside	2	5½
Diameter of chimney inside at top	1	6¼
" " " at bottom	1	0¾
Height of chimney above top of smokebox.	3	10

Heating surface:

Tubes (outside)	922¼	square feet.
Firebox	89⅓	"
Total	1011¾	
Firegrate area.	16.4	square feet.

Wheels and Axles:		
Diameter of driving wheels	7	1
" leading "	4	1
" trailing "	4	1
Distance between centres of leading and driving wheels	9	6
Distance between centres of driving and trailing wheels	7	6
Total wheel-base	17	0
Bearings of Driving Axles:		
Diameter	0	7
Length	0	7
Bearings of Leading and Trailing Axles:		
Diameter	0	5
Length	0	10
Diameter of axles at centre	0	5
Cylinders:		
Diameter	1	5
Stroke	2	0
Length of ports	1	2
Width of steam ports	0	1½
" exhaust ports	0	2½
Working Gear:		
Length of connecting-rods between centres	5	9
Diameter of bearing at large end	0	7
Length " " "	0	4
Diameter " small "	0	3
Length " " "	0	3
Width of guide bars (double)	0	2½
Length of crosshead blocks	0	10
Diameter of piston-rods	0	2⅝
" valve spindles	0	1¾
Length of eccentric rods between centres.	5	2½
Frames:		
Length of frames outside buffer-plates	23	4
Thickness of inside frames	0	1¼
" outside "	0	0⅞
Depth of inside frames between cylinders and driving horn-plates	1	5
Depth of inside frames between driving and trailing horn-plates	1	3
Depth of outside frame between horn-plates	1	0

Weight of Engine Empty:

	tons.	cwt.
On leading wheels	9	13
On driving wheels	12	12
On trailing wheels	8	0
	30	5

The steam pressure carried is 130 pounds; the tractive force about 7,000 pounds; the regular speed 44 miles per hour, exclusive of stops. The tyres, axle-box guides, crank axle, guide bars, and piston-rods are of steel. The engine is fully illustrated in "Engineering," Oct. 9.

THE PHŒNIX MILLS, at Seneca Falls, N. Y., are the largest of their kind in this State. They comprise 3 buildings of the following dimensions: 200 by 70 feet, 150 by 50, and 120 by 65, with a warehouse 200 by 45, They contain 26 sets of woollen machinery of the most improved patterns. The working force of the mills is 1,000 hands.

OLD AND NEW WAYS OF BREAD-MAKING.

From the "American Artisan."

There is probably no substance used for food that has been made from a greater diversity of materials or by a greater variety of ways than bread, and very few which possess greater elements of interest to the general reader or the student of practical science.

It is believed that the earliest loaves were made at a period anterior to the invention of even the oldest grinding or pulverizing devices, by simply soaking grain in water until it became soft and pulpy and then pressing it into cakes, which were baked in the camp-fire embers where the rude and wandering tribes pitched their tents each night. It was but a slight advance on this to bray or pound the wheat, millet, or other grain in a mortar, and, after moistening the powdered mass, spreading it upon a hot surface to bake, or placing it wrapped in leaves in the hot ashes for the same purpose; yet this, almost the first and primitive method of bread-making, has obtained, with a simple change in the mode of pulverizing, to this day. When the Hebrews dwelt in the land of Goshen they baked the *huggoth*, or little cakes of unleavened bread, under the ashes or upon the hearth. In recent times the far-famed oat-cakes of Scotland have been made by wetting the coarsely bruised or powdered oats with water having a little salt dissolved therein, and after rolling the mass into a thin sheet placing it before the fire. Bannocks are said to be made in the same way in India, and in our own country bruised corn-meal spread wet upon a shingle, placed aslant in front of the hearthstone fire, constituted the johnny-cake that made the greater part of the pioneer's daily fare. The method of baking under the ashes is still followed by the women in Bulgaria when bread must be made in haste, so as to meet the wants of travellers; and the hoe-cake of the South owes its charcoal crust to the same process. The making of bread is also characterized by the unique nature of the materials used; for instance, the Laplanders, having no grain, make a kind of bread of dried and pulverized fishes and the inner bark of the pine-tree, and in Sweden and Norway the wood of beech and similar trees which contain no turpentine is sometimes converted into bread. This is done by macerating the wood in water, and boiling it to remove the soluble matter. The wood thus macerated, after being heated several times in a suitable oven, is reduced to a fine powder by grinding. It is asserted that this wood-flour much resembles that made from corn, having a yellowish color and being capable of fermentation on the addition of yeast, and furthermore producing loaves of uniform and spongy texture. This flour also yields by boiling in water a thick jelly something like that made from wheat-starch. Pulverized pine bark is very often mingled with rye-flour in Northern Europe.

The bread made according to the simple methods above described may all be classed as unleavened bread, but the use of barm for making raised bread was known as far back as the time of Moses; and its employment passed from Egypt to Greece and Italy, and afterwards to all the northern nations conquered by Roman arms. No other means of making light or raised bread were ever known until within a comparatively recent period, when the same spirit of progress that revolutionized other departments of industry led to improvements in the art and mystery of making the staff of life. A mention of some of these last may be of interest.

Aside from convenience in the process of making, one great object sought to be secured by the recent methods is to obviate the loss resulting from the fermentation produced by yeast, and which has been variously estimated at from 2 to 10 per cent. of the entire weight of flour. To effect this object the bi-carbonate of soda and hydrochloric acid have been sometimes brought into use, there being intimately incorporated with every 4 pounds of flour employed 320 grains of the powdered bi-carbonate. To the flour thus prepared is added a solution composed of 300 grains of common salt, $6\frac{1}{2}$ fluid ounces of hydrochloric acid, and 35 ounces of water. The dough being kneaded is placed in the oven for baking in the ordinary manner. The acid combines with the soda of the bi-carbonate, converting it into common salt which is left in the bread, and disengages carbonic acid which puffs or swells it up in the same way that the carbonic acid liberated by the action of leaven brings about the same end. Another plan, most frequently adopted in making rusk, gingerbread, etc., involves the use of the sesqui-carbonate of ammonia, which, when the dough is heated, is converted wholly into a gas and passes off, leaving the bread in the form of a light spongy mass.

There is also a different plan of making what is known as aërated bread, in which the dough is placed in a box, and mixed by machinery with water charged with carbonic acid. When the dough is taken from the box where it is thus mixed under pressure, the carbonic acid escapes from the water and "raises" the bread, so that by this means not only is all loss of flour prevented, but the process, instead of requiring 8 or 10 hours, as by the common mode, may be completed in 30 minutes.

TELEGRAPH ENGINEERING IN 1868.

The progress of telegraphy during the past year has not been distinguished by any remarkable invention, and generally telegraphic extensions in this country have been checked by the contemplated assumption of the telegraphs by the Government. Messrs. Siemens have projected and commenced, in connection with our North Sea cables, an extended aërial telegraph through Prussia, Russia, and Persia, to join our Indian lines at Teheran, and though rival interests are striving very hard to cry down this route in favor of submarine lines through the Mediterranean and Red Sea, we have no doubt that the known ability of the contractors, and the manifest superiority of a well-constructed land line over the uncertain durability of a submarine cable, will make this telegraph the favorite "silent highway" to the East

Immense stimulus has been given to submarine telegraphy. There are more miles of cables in construction at the present moment than at any previous period of telegraphic history, and during the past year new cables have been submerged—between Malta and Alexandria, 900 miles; between Sunderland and Denmark, 340 miles, and between Florida and Cuba, 110 miles—though this last is not yet completed, owing to the expedition running short of cable. Sir Charles Bright is now engaged in completing his difficult task. The Danish cable is remarkable for being the first cable of any length constructed with Hooper's insulated core, and 500 miles of cable of the same material are now coiled in the tanks at Henley's works, waiting submersion in the Persian Gulf. The largest submarine project of modern days, the French Atlantic cable, is making rapid strides at the gutta-percha works and at the telegraph construction works at Woolwich. It is expected to be laid in August. It consists of 3,047 miles of rope, and it will be submerged from the same ship and by the same experienced hands that were engaged over the previous cables.

During the year Professor Wheatstone received the just reward of a knighthood for his numerous and beautiful inventions in telegraphy.

The Atlantic cable broke near Newfoundland, and was readily repaired. This is the second time such an accident has occurred. Many other such accidents have happened during the year to other cables, including the Persian Gulf, the Malta and Alexandria, the Dunwich and Zandvoort, the Lowestoft and Zandvoort, the Sicilian and Algerian, etc. The maintenance of submarine cables has become an important and valuable branch of the engineering profession, and the experience of our engineers has shown that repairs to cables are practicable in all depths. Considerable confidence in such enterprises has been engendered, and the public are becoming far more liberal in their contributions towards this vast field for investment. China and Australia cannot long remain beyond the pale of the electric spark.

The all-absorbing domestic question of the day is the purchase of the telegraphs by the State. This is expected to be completed in June. The telegraphs will pass to the control of the active executive of the Post-office, and the public will be great gainers by the exchange. How the professional branch is to profit or suffer remains to be seen.—*Engineering.*

WATER-POWER in Maine, according to a State report, consists of above 2,000 different "privileges" of an aggregate of 300,000 to 600,000 horse-power.

Ship Canal from Oswego to Albany.—It is proposed to construct a ship canal from Oswego to Albany by enlarging the Erie Canal from Albany to Oneida Lake, thence along the head of the lake and down the Oswego river. The lockage is 230 feet. With this canal, vessels loaded with grain could sail from Chicago to Liverpool by way of New York, avoiding the difficult navigation of the St. Lawrence river.

Furniture-making in Italy.—The Italian cities were famous in the middle ages, but not more famous than at present, for the production of furniture and house and church decoration in wood, not only in large quantities, but of light and tasteful designs. The principal modern works of Barbetti, at Florence, employ about 100 workmen, and turn out a value of half a million dollars per annum. At Milan there are 30 smaller manufactories, employing some 250 men. The more beautiful of their productions are in carved woods and in marqueterie work, inlaid with metal and enriched with ormolu or colored stones, or miniatures and pictures in majolica. In various parts of the province of Milan this manufacture gives employment to 350 families. Here, as well as in the Venetian provinces and about Naples, much cheap as well as costly furniture is produced. At the principal works in Florence, Milan, Turin, and Naples, wood-working machines driven by steam are considerably employed.

Winans' Cigar Steamships. — However opposed the principles of Messrs. Winans' construction may be to the general practice, it should appear that they have not been arrived at without long and costly preliminary experiment. The "London Times" details experiments made by Mr. Winans long since, in Baltimore, with various forms of hull and frictional surfaces, and states that Mr. Winans' plans are soon to be tested on the large scale of ocean navigation.

Australian Coal, equal to the English North Country coal, is worth 7s. to 9s. per ton at Sydney, the mines being 5 to 7 hours distant, near the coast.

WORKING PLANT AND APPLIANCES.

From "The Building News."

Human invention and ingenuity are ever on the stretch to keep pace with the contingencies that are daily and hourly occurring, and are the inseparable attendants of an age of reason, enlightenment, and national education. No sooner is one improvement patented and given to the public than another springs up superior to its predecessor, and after that another, and so on until man's inventive faculties are racked and the powers of imagination strained to the utmost to meet the ever-increasing demands.

Notwithstanding that the aid of machinery has been called largely into requisition in the construction of engineering and architectural works, yet many of the processes and operations still continue to be carried on by manual labor. Earthwork is still nearly universally performed by hand. The old system of laying down temporary rails, filling the "lorries," and tipping them over the "tip head," is still practised, and will be for a long period to come. Where the excavation takes the shape of a tunnel, special machines are used, as in the case of Mont Cenis, which is an example upon the largest and most successful scale that has ever been attempted. A marked improvement was visible in the construction of engines, movable cranes, and other mechanical appliances for raising loads at the recent "Exposition," in comparison with the specimens exhibited at previous international displays; they were much simpler in construction, better finished with respect to fitting and workmanship, more practical in design, less costly, and better adapted for rapid manipulation, and less likely to cause accidents and mishaps among those working them.

Except in comparatively insignificant instances, the old system of scaffolding for house building is completely obsolete. Contrast the methods at present employed in the erection of the new mansions on the estate of the Marquis of Westminster with the more ancient system, wherein round larch and fir poles and rope lashings formed the prominent features. We replace manual labor in what might be termed the transference of materials by the agency of movable cranes running upon strong timber traverses; and in this respect our system, as a whole, is superior to that of our French neighbors. There is no country where the erection of buildings, so far as modern inventions and conveniencies are concerned, has made so little progress as France. Notwithstanding that there is an abundance of more favorable appliances at hand, she continues to employ the ancient methods in spite of their slowness and cost.

One especial point in which there is a marked distinction between us and continental nations is in the substitution of iron for timber. Among ourselves this is now almost universal. An engineer would never dream of erecting a timber bridge except upon a scale of the most trifling character, nor, in fact, were it intended for railway traffic, would the Board of Trade sanction it. Cast and wrought-iron joists and beams are now the ordinary supports in warehouses and large buildings, to the almost entire exclusion of timber. The case is otherwise in France, where heavy balks are still employed in situations that we should now never think of their occupying. Recently iron wire has been used there with great success instead of ropes for scaffold fastenings. From very early times the Italians have been in the habit of adopting a peculiar description of scaffolding in which very short timbers are used, and the erection of which is carried on with extreme rapidity and considerable solidity. It is quite possible that if this system were modernized, and received the benefit of all the recent improvements and modifications, it might prove a very valuable one.

It might be supposed, from what has been stated respecting the substitution of iron for timber, that the trade of the carpenter had declined, and had, in fact, become merged in that of the smith. To some extent this is probably true, but not to a degree sufficient to affect the absolute earnings of the former. Permanent iron constructions of the present day demand an amount of carpenter's work for temporary purposes, far exceeding what was required for the permanent timber erections of bygone times. Let any one take a glance at the forest of piles, uprights, horizontal trussing, bracing, strutting, and centering, that obstruct the river at Blackfriars, and it will be more than sufficient to assure them that timber and carpentry still play a very considerable part in engineering and architectural structures.

Machinery has been established on the most improved system and on the most extensive scale for fashioning the timber-work intended for the interiors of houses; sawing, planing, mortising, tenoning, and all the other operations once performed solely by hand labor, are now accomplished by the agency of machines. It is rather curious that the principal railway terminus in Munich was one of the first instances abroad where all the timbers were prepared by machinery. Germany and our own country were the two foremost in availing themselves of the aid of steam power for this purpose.

The real merit of substitution of machinery for manual labor is undoubtedly due to the Americans, and in their case was a practical illustration of the old adage, "Necessity is the mother of invention." From a scarcity of manual labor, an inconvenience that all young countries suffer from, she was obliged to invent some means of accomplishing by machine power what was effected in more populous countries by hand labor. It is often said that the Americans invent, but we improve, and there is much truth in the remark. The reason is easily found, and the validity of the observation confirmed. The Americans have not the time to perfect any invention; they are daily, almost hourly, in want of it, and are compelled to utilize it before it has received that finish and those nice adjustments which in reality constitute the whole mechanical beauty of the machine. When the crude material comes to us we have leisure to examine it and it therefore receives from us that remodelling and final improvement which the urgency of the case did not admit of in the land of its birth.

Silsby's Fire Engine Works at Seneca Falls, N. Y., comprise 2 machine shops, 120 by 45, and 60 by 45, a foundry 90 by 50, a smith shop 75 by 50, a boiler shop 40 by 40, a paint shop, brass foundry, etc. They employ 160 men, and have built over 200 steam fire engines, besides various steam and pumping machines and hydraulic fittings. The Silsby pumps are rotatory instead of reciprocating.

THE IRON WORKS OF LE CREUSOT.

Condensed from the Correspondence of the "Mining Journal."

Few travellers through Burgundy, and more especially that portion of it purple in the summer's prime with the luscious fruit of the vine, would imagine that it has its black country. But a cloud of smoke persistently hangs over a portion of it—smoke from the iron works of Le Creusot, which, from the small proportions of a local forge, set up in 1769, have grown to be among the most important and extensive in Europe.

The best and easiest route to Le Creusot is by the railway which branches from the Paris and Lyons line a little south of Beaune, to Montchanin, and from thence by another line communicating with Nevers, which passes close to the works. Le Creusot now has a population exceeding 25,000 souls, all more or less connected with the works. In 1782 Le Creusot bore the name of Charbonnières, given to it in consequence of the discovery of coal near the village and close to the surface of the ground. The discovery having been communicated to Louis XVI. a company was formed, under his patronage, to work the mine; and as laborers were scarce, the king placed a regiment of soldiers at the disposal of Gauthey, engineer-in-chief to the States of Burgundy, who was appointed to open the mine. Shortly after a steam engine, constructed by Watt, was brought over from England, the cylinder of which is carefully preserved as an interesting relic. By means of this engine considerable quantities of coal were raised, and the almost simultaneous discovery of iron ore near the coal gave a fresh stimulus to the company. By order of Louis XVI. and on his death by that of the chiefs of the revolution, a great number of cannon and cannon-balls were cast here ; and the hill where the guns were proved and tried was called Les Boulets, by which name it is still known. After the revolution Le Creusot passed into the hands of the brothers Chagot, under whose direction various iron works were erected and all the gas-pipes for Paris made. In 1826 the above gentlemen disposed of the works to an English company—Manby and Wilson—for the sum of 2,620,000 frs. But the concern did not prosper in their hands—the company collapsed; and in 1837 the establishment was purchased by the Brothers Schneider, one of whom had been long engaged in commerce in Paris, while the other had been trained among the forges of the Ardennes. An unfortunate accident terminated the life of the elder of those brothers in 1845, since which period the management has been in the hands of M. Eugène Schneider (the well-known President of the French Corps Législatif), who has developed its resources to their present gigantic proportions—how gigantic may be conceived from the fact that while in 1837 the workmen did not exceed 1,000, they now number 11,000.

The greater portion of the iron ore worked at Le Creusot is obtained from Mazenay, at the junction of Burgundy and Maconnais. This ore yields 28 per cent. of iron, and extends over a vast area. The vein, which in no place is more than 130 feet from the surface of the ground, averages 6½ feet in thickness. The present annual yield is 262,000 tons. The ore is conveyed by a special railway to Le Creusot, where it is passed through enormous blast-furnaces of the most approved construction. Large as is the supply of iron ore from Mazenay, it does not meet the requirements, and other mines feed these great works. Among these is the famous Algerian Mine of magnetic iron ore at Mokta-el-Hadid, which yields no less than 65 per cent. of excellent iron, and of which large quantities are now shipped to Dunkirk, where it is sold at 1*l.* 8s. 10d. per ton.

To meet the great and continually increasing demand for steel, enormous works for carrying on the Bessemer process are being erected, which, when completed, will extend the total area of the works to 357 acres. But perhaps the most impressive department of this establishment is that of the forges, contained in a shed covering no less than 29.65 acres, and containing 68 steam-hammers, 672 machines of various kinds, and 85 steam-engines.

With respect to steam-hammers, it is due to our neighbors to state that they claim the invention of this most useful machine for their countryman M. Mourdon, who took out a patent for its construction in April, 1842, whereas Mr. Nasmyth, to whom the invention is generally attributed, did not, as they say, take out his patent in England until June in the above year, having, moreover, visited Le Creusot between the above months.

The shed containing the workshops for the construction of locomotives, marine and the other steam-engines, iron bridges, pontoons, etc., is scarcely inferior in extent to that devoted to the forges. It contains 37 steam-hammers, and 567 machines of various kinds. Locomotives are building here for nearly all the States in Europe.

That the flourishing condition of Le Creusot is partly due to the enormous supplies of iron ore and coal at its very door is unquestionable; but credit must be also given to the admirable management prevalent throughout all the departments. Its large and continually increasing business must also be ascribed, in a great measure, to the fact that the wages of the skilled workmen are below those received by English operatives of the same class. According to the information communicated, the wages paid to plate-rollers is 10 frs. for 10 hours' labor, and the first-class workmen engaged on locomotives receive only 5 frs. The average daily wages of all the workmen is now 3 frs. 45 cents. Low as these wages are, compared with those paid to English artisans in our iron works, the prices of provisions at Le Creusot are such as to enable the operatives to live comfortably within their incomes. The rent of a house, containing 3 rooms, varies from 100 to 125 frs. per annum; and the average living expenses of a family consisting of 3 persons is stated to be 1 fr. 50 cents per day. Great facilities are given to the workmen to purchase the houses which they occupy. The average cost of these is 1,800 frs.; and at present 2,131 workmen own the houses in which they live. Several excellent, and almost gratuitous schools exist in the town, the payment exacted being only 75 cents. per head monthly. Boys are taught reading, writing, grammar, arithmetic, and drawing; and those who manifest intelligence, and a decided capacity for mechanics, are sent, at the expense of the company, to the High School of Arts and Métiers at Aix, from whence they are drafted to Le Creusot when their education is completed.

From a statistical document, it appears that during the 15 years ending 1865, out of the entire population only 632 persons were sentenced to punishments for crimes, and these were of very light nature. Drunkenness—that curse of our country—is very rarely seen at Le Creusot; and woman beating, which disgraces English working communities, is, it may be said, entirely unknown.

Mineral Wealth of Missouri.—There are three copper fields in Missouri. These extend through Franklin, Crawford, Dent, Shannon, Wayne, Madison, and Iron counties, and include 500,000 acres of copper lands. The practical geology, topography, surface signs, and ores discovered and mined in these copper fields, indicate that the repletion, or filling of these copper veins, is on a scale of magnitude corresponding to the iron-producing action that formed the Iron Mountains. No copper has been mined in Missouri since 1856.

There are 2,000,000 acres of lead fields in Missouri; 30,000 acres have been mined and yield $25,000,000 worth of lead. This lead was made from ore from "clay diggings," which is the croppings of veins in the rock.

The value of pig-iron made in Missouri in 1867 was about $1,000,000, lead $300,000; no copper, zinc or nickel. Value of pig-iron made in Pennsylvania in 1867, in round numbers, $30,000,000. Missouri contains a much richer character of iron ores than Pennsylvania, and ten times the quantity.—*Iron Age.*

The Petroleum Trade.—Philadelphia ships about half of the petroleum sent abroad from the United States. Pittsburgh is the principal market for the article west of the Alleghanies. From January 1st to November 14th of the year just past, Philadelphia exported 33,665,224 gallons of petroleum. In the same period, the exports from Boston amounted to 2,267,517, and from Portland 580,400 gallons. During the same period in 1867, the exports from Philadelphia to foreign ports were 25,621,005 gallons, showing an increase this year of upwards of 8,000,000.

CARBON IN STEEL.—Hardened steel leaves no carbonaceous residue on solution in muriatic or diluted sulphuric acids; unhardened steel also leaves none when dissolved at as high a heat as possible with exclusion of air; but it leaves such a residue when solution is not at first or at the proper time aided by heat. This residue is not dissolved by further heating.

Percentage of	Comb. Carbon.	Graphite.	Total Carbon.	Nitrogen.
Cement steel unhardened drawn under hammer and hammered cold......	1.20	0.30	1.50	0.016
Cement steel unhardened drawn........	1.24	0.30	1.54	......
Cement steel hardened drawn........	1.48	0.02	1.50	0.016
Bessemer steel unhardened No. 2........	2.02	0.20	2.22	0.005
" " " 3½......	1.17	0.10	1.27	0.005
Bessemer's steel hardened " 3½......	1.28	0.00	1,28	0.005
Bessemer steel without spiegeleisen, red short..................	......	......	0.40	0.006
Bessemer steel with spiegeleisen not, red short..................	......	......	0.45	0.008

—RINMAN *in Erdman's Journal.*

WOOD suitable for cabinet making and decoration, according to a report on the woods in the Paris Exhibition, exists in much larger quantities and of much greater variety than is generally supposed. But a small number of the hard and beautifully colored and variegated woods that are accessible in various countries, have been brought into use.

Another report magnifies the value of wood to the world, deprecates the reckless waste of timber in new countries, and advocates the enactment of better laws for the preservation of forests.

THE STRENGTH OF CORRUGATED IRON.

BY J. E. HART, C. E.

From the "Bombay Builder," August, 1868. With comments by Professor Rankine, from "The Engineer," November 13, 1868.

The following are the experiments on the transverse strength of corrugated iron, alluded to in a letter published in the May number of the above journal:

The iron experimented on was supplied by Messrs. Nicol & Co., Bombay, and supposed to be of the following gauges: 8 BWG, 10 BWG, 12 BWG, 16 BWG, 22 BWG. The sheets or plates were supported on trestles, and loaded in their middle by weights suspended in a scale pan. The bending action of the load was distributed along the transverse axis by a rigid bar of timber laid across the sheet at right angles to the corrugations, and the pressure of this bar was distributed to ridge and furrow by a layer of damp sand. Fastened to this bar by a cotter was a flat strip of steel, which, passing through a slot in the sheets, suspended a stirrup with an universal joint carrying a roughly made scale beam. The dimensions of the slot were three-fourths of an inch long by one-fourth of an inch wide.

The object of this arrangement was to obviate any unequal strain on one side or other of the sheets through the oscillations of the load in the scale pan. The tressles were movable along sleepers sunk in the ground, so that the bearings of the sheets could be altered at pleasure. The deflections were measured with a scale of 50ths of an inch, which was hung from the lower side of the sheets between silk threads stretched by weights between the tressles. The thicknesses of the sheets were measured with a scale of 100th of an inch, read off with a magnifying glass. The sheets broken were of various lengths in order to test the accuracy of the formula; for the same reason the bearings were made to vary; and in order that the comparison might be closer several of the broken sheets were again subjected to experiment. The constant, or modulus of rupture arrived at, is on the whole sufficiently uniform, and establishes fairly Professor Rankine's approximate formula for the moment of resistance of corrugated iron (see "Manual of Civil Engineering," chap. v., sec. iv., art. 375).

$$\frac{4}{15} f \frac{hbt}{a} \ldots$$

which equated with the bending moment for a central load gives—

$$\frac{4}{15} f_a h b t = \frac{W l}{4} \text{ whence}$$

$$f_a = \frac{15 \text{ W} l}{16 h b t}$$

by which formula the modulus of rupture fa is calculated.

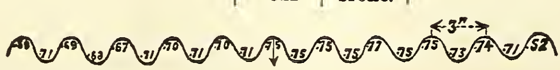
In the formula :

W = The total load in pounds;
h = The height of the corrugations measured from ridge to furrow;
b and t = The breadth and thickness respectively of the sheets in inches;
l = The bearing or span between supports in inches.

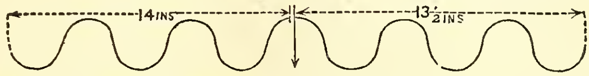
The heights of the corrugations were found to be very unequal, not only in adjacent ridges and furrows, but also in different parts of the same furrow. The heights given in the data are the average of all across the sheet in the middle, as shown in the sketches of the section. The outer corrugations, unless the plate was expressly cut, were not of the full depth; and their heights were rejected as an element of strength. The thicknesses varied in different sheets of the same gauge, and also slightly in different parts of the same sheet. They were measured from a piece cut out of the sheet, and carefully filed true; in a few cases, however, did they correspond with the tabular value of the thickness of the supposed gauge of the sheets. The placing and removal of the loading was effected through the medium of a lever and screw-jack, which arrangement obviated any chance of a jar of the material from jerks or vibrations of the load. Every care was taken to avoid inaccuracy, either of observation or of result.

No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Dimensions of Sheet and Remarks.
1	Gauge No. 22 (probably)...............	164	·60	t = .029 inches.
		220	.82	l = 60 inches.
	Size of sheet, 8′ × 2′–3″....	234	.88	b = 27 inches ∴ fa = 46567 lbs. on sq. in.
	Weight of sheet, 28 pounds............	248	.92	h = 67 inches.
	Do. per square foot, = 1.56 pounds.....	262	1.00	
		276	1.08	Yielded slowly on adding last weight by tearing off lower corrugations on each side of slot in middle.
		290	1.14	
		304	1.22	
		430	broke.	

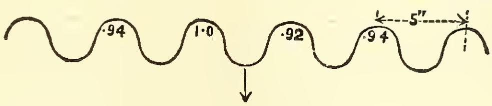
No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Dimensions of Sheet and Remarks.
2	Gauge No. 20.........................	90	.18	t = .035 inches.
		146	.28	l = 60 inches.
	Size of sheet, 6′ × 2′–7¾″..............	202	.40	b = 31.75 inches ∴ fa = 45628.
	Weight of sheet, 29 pounds............	258	.52	h = .71 inches.
	Do. per square foot=1.83 pounds	314	.64	
		370	.78	
		426	.96	
			ultimate	
		640	6.8	
		641	broke.	



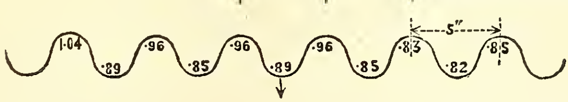
No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Dimensions of Sheet and Remarks.
2*a*	Uninjured end of above sheet rebroken .	1448	broke	l = 30 inches. h = .72 inches. ∴ *fa* = 50900.
3	Gauge No. 17 .... Size of sheet, 6′ × 2′ − 3½″.............. Weight of sheet, 38 pounds............. Do. per square foot = 2.76 pounds.....	.46 102 158 214 382 1161	.08 .12 .20 .31 .40 broke	t = .06 inches. l = 60 inches. b = 27.5 inches . ∴ *fa* = 41663. h = .95 inches. Two separate sheets with weight hung between the right-hand sheet failed first.



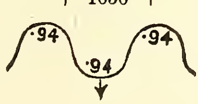
No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Dimensions of Sheet and Remarks.
3*a*	Uninjured end of above sheet rebroken .	1018	broke.	l = 30 h = .86. b = 3.5 . ∴ *fa*=41101
4	Gauge No. 17 .... Size of sheet, 6′ × 2′ − 3¾″.............. Weight of sheet, 33½ pounds........... Do. per square foot = 27.7 pounds	160 272 384 496 720 1224	.12 .22 .34 .46 .72 broke	t = .06 inches. l = 60 inches. b = 27.75 inches. ∴ *fa* = 43528. h = .95 inches. Yielding slowly with puckering of the top corrugation, and spreading at sides.



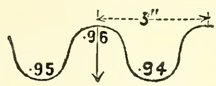
No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Dimensions of Sheet and Remarks.
5	Gauge No. 13 or 12.................... Size of sheet, 6′ × 2′ − 9″............... Weight of sheet........................ Do. per square foot....................	260 596 1044 1794 1895 2114 2160	.28 .46 .68 *a* *c* *d* broke	t = .096 inches. l = 60 inches. b = 33 inches. h = .9 inches. *a* here received a shock from slipping of lifting tackle. *c* do. do. do. *d* plate began to sink visibly, giving most at side where h was least.



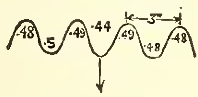
No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Dimensions of Sheet and Remarks.
6	Guage No 12......... .... Size of sheet, 6′ − 0¼″ × 0 − 10.1″........ Weight of sheet, 24.5 pounds .... Do. per square foot, 4.84 pounds	151 263 375 487 599 1050	.12 .20 .30 .38 .46	t = .1 l = 48 inches. b = 10.1 inches . ∴ *fa* = 49770. h = .94 inches.



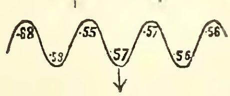
No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Dimensions of Sheet and Remarks.
6*a*	Uninjured end of above sheet rebroken..	1768	....	$1 = 30$ inches $\therefore fa = 52376.4$.
6*b*	Do. do. do. ..	2210	....	$1 = 24$ inches $fa = 52374.6$.
7	Guage No. 12........................	152	.10	t = .1
		264	.18	l = 48 inches.
	Size of sheet, 6′—0¼″×0′-99″..........	376	.26	b = 99. inches $\therefore fa = 46124.4$.
	Weight of sheet, 23.5 pounds..........	488	.30	h = .95 inches.
	Do. per square foot, 4.73 pounds.......	600	.44	
		768	.60	
		964	broke	



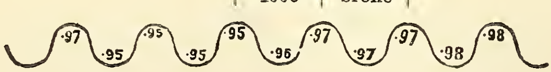
No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Dimensions of Sheet and Remarks.
8	Gauge No. 13 or 12....................	90	.44	t = .095 inches.
		146	.72	l = 60 inches.
	Size of sheet, 6′×1′..................	202	1.0	b = 12 inches $\therefore fa = 43099$.
	Weight of sheet, 27 pounds............	258	1.36	h = .49 inches.
	Do. per square foot, 4.50 pounds........	314	1.8	
		428	broke	



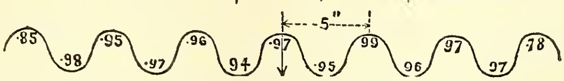
No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Dimensions of Sheet and Remarks.
9	Gauge No. 13 or 12....................	90	.34	t = .095 inches.
		146	.58	l = 60 inches.
	Size of sheet, 6′×1′..................	202	.80	b = 12 inches $\therefore fa = 41959.4$.
	Weight of sheet, 28 pounds............	258	1.04	h = 56 inches.
	Do. per square foot, 4.66 pounds........	314	1.26	These two sheets 8 and 9 are rolled
		426	2.10	to sharper curves at the corruga-
		...	ultimate	tions than others, and approach
		480	2.78	the zigzag form. They are also
		483	broke	got from the same whole sheet cut
				in half, and show a curious dis-
				crepancy in the height of corruga-
				tions.

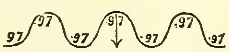
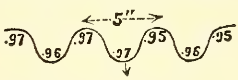


No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Dimensions of Sheet and Remarks.
10	Gauge No. 12 or 11....................	212	.12	t = .12 inches.
		436	.20	l = 60 inches.
	Size of sheet, 6′×2′—9″...............	660	.26	b = 33 inches $\therefore fa = 58940$.
	Weight of sheet, 103 pounds...........	884	.32	h = .964 inches.
	Do. per square foot, 6.24 pounds........	1108	.36	
		1332	.44	
		1780	.56	
		4000	broke	



No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Description of Sheet and Remarks.
11	Gauge No. 12 or 11	90	.06	t = .115 inches.
		202	.10	l = 60 inches.
	Size of sheet, 6′×2′–9″..............	426	.20	b = 33 inches ∴ fa = 46373.
	Weight of sheet, 88 pounds............	650	.30	h = .964 inches.
	Do. per square foot, 5.34 pounds.,......	762	.34	
		900	.40	
		1251	.58a	a, Load removed, plate returned to the horizontal.
		2750	.18	
		3072	broke b	b, Ultimate deflection observed at 3000 was 4′ 6″.



No. of experiment.	Description of Sheet.	Weight in Pounds.	Deflection in Inches.	Description of Sheet and Remarks.
12	Gauge No. 9...........................	202	.18	t = .15 inches.
		426	.36	l = 60 inches.
	Size of sheet 6′×1′–3″................	650	.50	b = 15 inches ∴ fa = 47760.
	Weight of sheet, 49 pounds............	874	.60	h = .97 inches.
	Do. per square foot, 6.53 pounds	1110	.84	
		1334	1.02	
		1558	1.40	
		1850	broke	
13	Gauge No. 2..........................	202	.20	t = .15 inches.
		426a	.36	l = 60 inches.
	Size of sheet, 6′×1′–3″.............	650	.52	b = 15 inches ∴ fa = 43281.
	Weight of sheet, 47¾ pounds.....	874	.64	h = .96 inches.
	Do. per square foot, 6.36 pounds	1098	.80	
		1322b	1.02 ult. def.	a, Outer edge began to cripple. b, Load removed and sheet returned to deflection of .94 only.
		1660	2.84	
		1662	broke.	

Mean value of fa = 46682 from all experiments, or = 46916, omitting No. 10.

It appears from these experiments that the highest and lowest values of $f\ a$ are respectively 58,940 and 41,101; the former of these extreme values I would reject as open to suspicion, because of the great discrepancy between the breaking load of it, and its sister sheet (No. 11). The mean value of $f\ a$ from the remaining experiments would be, as nearly as might be, 46,000, and this may, I think, be adopted as its true value. Experiments 2, 2a, and 6, 6a, show that the strength varies inversely as the length, although a slight of increase of strength appears in the shorter sheets, which may be accounted for by the deflection being less. The breadth does not appear to influence the constant, so that we may assume the strength to vary as this dimension. The depth also of corrugation does not appear to influence the result other than directly; that is, however, a point that could only be examined by having similar sheets rolled of varying depths of corrugations. However, Experiments 5, 8, and 9, afford a comparison as far as it goes. Experiments 6, 7, 12, and 13, show that in narrow sheets the position of the side edge, whether in tension or compression, makes a difference. This would appear to be a necessary consequence of the laws of strength of materials, and it was observable that when the side edges of the plates were up, as in Experiment 7, the edges cripped early in the experiment; while when they were down, as in Experiment

6, they did not fail till later. All plates first showed symptoms of failure at the side edges. None of the plates gave way suddenly, but each sank slowly when the breaking weight had been reached. As a rule, they appeared to fail by the spreading of the corrugations at the middle, and did not crush at the tops of the ridges; on the contrary, when the sheet was allowed to sink till rupture of the material took place, fracture occurred by tearing of the furrow commencing from each side of the central slot, and proceeding towards the sides of the sheet at right angles to its length.

It is probable that had the sheet been prevented from spreading by strips riveted across it, as recommended by Professor Rankine, the constant would have increased in value. In bridges the adjoining sheets would act so as to oppose the spreading, and this may be looked upon as an element of strength. The results of the observations of the deflections seem to be uniform, but at present no deductions from them are made. The ultimate deflections were in a few instances observed as a matter of curiosity, but in most cases it was not possible to hit off the very extreme deflections. I find that the increased value of the constant or modulus of rupture derived from the preceding series of experiments will so considerably modify the conclusions of my former communication that it is desirable that I should revise some of my previous calculations, and I therefore venture to go over some of the ground again, connecting and enlargening some of the deductions I have already made.

REMARKS BY PROF. W. J. MACQUORN RANKINE.

1. Reference to Mr. Hart's Researches.—A valuable series of experiments by Mr. Hart, on the transverse strength and stiffness of corrugated iron, have been published in the "Bombay Builder" for August, 1868, and reprinted in "The Engineer" of the 10th October, 1866, page 298. Mr. Hart shows that the results of those experiments agree very fairly with a formula proposed by me a few years ago* for the breaking moment of a sheet of corrugated iron, viz:

$$\frac{Wl}{4}=\frac{4}{15}fhbt; \quad \cdot \cdot \quad (1)$$

* "Manual of Civil Engineering," page 543.

in which l denotes the span; W, the breaking load hung at the middle of the span; b, the breadth of the sheet, and t, its thickness; h the depth of the corrugations from ridge to furrow; and f the coefficient or modulus of rupture. Values of that coefficient are calculated by Mr. Hart from his experiments by means of the following formula:

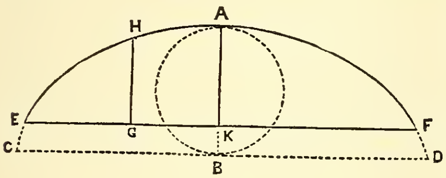
$$f=\frac{15}{16}\frac{Wl}{hbt}; \quad \cdot \cdot \cdot \cdot \cdot \quad (2)$$

and they are found to range from 41,100 pounds to 58,940 pound on the square inch; the mean value being about 46,000 pounds on the square inch. There can be no doubt then that the formula of Equation 1 may be safely used in practice to calculate the probable breaking load of sheets of corrugated iron of given dimensions; and that, in the absence of special experiments on the strength of the particular material that is used, the smallest of the values deduced from Mr. Hart's experiments, viz., 41,100 pounds on the square inch, may be taken as the modulus of rupture in the calculation.

2. Objects of this Communication.—The objects of the present communication are to explain the theoretical reasoning on which the formula of Equation 1 is founded, and the extent to which it is approximative; to determine, by the aid of Mr. Hart's experiments on breaking loads, values of the modulus of rupture according to a rule which gives a closer approximation; and to deduce, from his experiments on deflection, values of the modulus of elasticity of corrugated iron.

3. Assumption of a Cycloidal Cross Section.—The first step towards finding formulæ for the transverse stiffness and strength of a given piece of material, is to determine the geometrical moment of inertia of the transverse section relatively to a horizontal axis passing through its centre. In a sheet of corrugated iron, the transverse section is a narrow band of uniform width equal to the thickness of the sheet, and of a wavy figure, composed of a series of curved arcs, alternately above and below the horizontal axis of the section. These curved arcs usually approximate nearly in shape to arcs of circles; and no material error in practice is occasioned by assuming for

their figure any curve which does not greatly differ from a circular arc. A cycloidal arc is such a curve; and it has geometrical properties which cause the calculation of its moment of inertia to be a very simple process; therefore the figure of cross section of each of the ridges and furrows of the sheet of iron will be assumed to be a cycloidal arc, such as E A F in the figure; where C A D represents a complete cycloid, traced by a point in the circle A B, which rolls on the



straight base line C D; and the chord E F, parallel to C D, is drawn in such a position as to cut off an arc E A F, in which the depth A K bears to the breadth E F the same proportion as in the corrugations of the iron. That is to say, let a be the width of one corrugation, measured *from ridge to ridge*, and h (as before) the depth *from ridge to furrow;* then the chord and the depth of the cycloidal arc are respectively,

$$E F = \frac{a}{2}, \text{ and } A K = \frac{\ }{2}.$$

4. Geometrical Moment of Inertia.—One of the geometrical properties of the cycloid is as follows: The perpendicular distance H G, of any point H in the arc, from a chord E F parallel to the base line, varies proportionally to the product H E $\times$ H F of the two parts into which the arc E A F subtended by the chord is divided by the point H. To express this in algebraical symbols, let the arc A E = A F = c; the arc A H = s, the greatest ordinate A K $= \frac{h}{2}$ (as before); and the ordinate H G = y; then we have

$$y = \frac{h}{2} \cdot \frac{(c+s)\,(c-s)}{c^2} = \frac{h}{2}\left\{1 - \frac{s^2}{c^2}\right\}.$$

Let $d\,s$ denote an indefinitely short or elementary arc, situated close to the point h. Then the geometrical moment of inertia of $d\,s$ relatively to the axis E F is $y^2\,d\,s$; and that of the arc A E is expressed by the following integral:

$$\int_0^c y^2\,d\,s = \frac{h^2}{4}\int_0 d\,s. \left\{1 - \frac{s^2}{c^2}\right\}^2 = \frac{2\,h^2\,c}{15};$$

which, being divided by the length c of that arc, gives, for the *square of its radius of gyration,*

$$\frac{2\,h^2}{15}.$$

To find the geometrical moment of inertia of the cross section of a sheet of corrugated iron, the area of that section is to be multiplied by the preceding expression for the square of the radius of gyration: that is to say, let A be that area, and I the moment of inertia; then

$$I = \frac{2\,h^2\,A}{15} \quad \ldots\ldots \quad (3)$$

5. Formulæ for Strength and Stiffness.—The following are the well-known general formulæ for the modulus of rupture f, and modulus of elasticity or stiffness E, of a beam of uniform cross section loaded in the middle:

$$f = \frac{h}{2\,I} \cdot \frac{W\,l}{4}; \quad E = \frac{W'\,l^3}{48\,I\,v};$$

in which W is the breaking load; W′ any load not exceeding the limits within which the deflection increases in the simple ratio of the load; and v the deflection with the load W′. When the value of I given by Equation 3 is substituted in these formulæ, they become respectively as follows:

$$f = \frac{15\,W\,l}{16\,h\,A}; \quad \ldots\ldots \quad (4)$$

$$E = \frac{5\,W'\,l^3}{32\,h^2\,A\,v}. \quad \ldots\ldots \quad (5)$$

6. Determination of Sectional Area—Use of a Virtual Thickness.—A rough approximation to the sectional area of a sheet of corrugated iron may be obtained by simply multiplying together the breadth and thickness; that is, making

$$A = b\,t \quad \ldots\ldots \quad (6)$$

This is the approximation used in Equations 1 and 2. It always gives too small a value of the area; and hence, in using it to calculate the probable breaking load of a sheet of corrugated iron with a coefficient taken from experiments on iron in other forms, the errors to which it leads are always on the safe side; and this was the reason which induced me to adopt it in the book already referred to. It is obvious, on the other hand, that in calculating the modulus of rupture from experiment by means of the same approximation, the value obtained is greater than the actual stress on the material just in the same proportion in which the exact sectional area is greater than the approximate sectional area.

The length of the cycloidal arc E A=c in the figure is given with an error in defect which in no case exceeds $\frac{1}{400}$ part, by the approximate formula:

$$c = \frac{a}{4}\left(1 + \frac{8h^2}{3a^2}\right) \text{ nearly;}$$

from which it appears, that a second approximation to the sectional area of the sheet is given by the following formula:

$$= \left(1 + \frac{8h^2}{3a^2}\right) b\, t \quad . \quad . \quad . \quad . \quad (7)$$

Considering, however, how much more precisely the operation of weighing can be performed on a thin sheet of metal than that of measuring its thickness, it is obvious that by far the most accurate way of determining the sectional area of the sheet is to calculate it from the weight of a given horizontal area; and such, accordingly, is the method employed in a new reduction of the results of Mr. Hart's experiments. Mr. Hart gives, in each case, the weight in pounds per square foot of the sheet of corrugated iron experimented upon. That weight, in the following calculations, is divided by 40 (being the weight in pounds of a plate of iron a foot square and an inch thick), to give what may be called the *virtual thickness* of the corrugated iron; that is, the thickness of a *flat* sheet of iron of the heaviness of 480 pounds to the cubic foot, and of the same horizontal area and weight with the corrugated sheet. The product of the breadth and virtual thickness gives the sectional area: that is,

$$A = b\, t' \quad . \quad . \quad . \quad . \quad . \quad (8)$$

in which t' denotes the virtual thickness.

It may be remarked that the value of A, as given by Equation 8, is found in most, though not in all, of Mr. Hart's experiments to be somewhat greater than that given by Equation 7. It is probable that this may be caused by the iron being compressed in the process of rolling to a greater density than 480 pounds to the cubic foot. It is clear, nevertheless, that Equation 8 is the preferable formula; for in calculating the modulus of rupture and the modulus of stiffness, it eliminates the effect of such compression of the iron.

7. Method of Calculating the Modulus of Rupture.—In calculating corrected values of the modulus of rupture, the method followed has been to multiply each of the values given by Mr. Hart by the ratio $\left(\frac{t}{t'}\right)$ in which the measured thickness used in his calculations, is less than the virtual thickness used in mine. The results are given in the annexed table (A). They are computed to three places of figures only, as it would be useless to attempt greater precision. The difference between the extreme values is less, as compared with the mean value, than in the case of the values deduced by Equation 2 from the measured thicknesses, as the following statement shows:

Values in pounds on the square inch deduced from

	Measured thicknesses.	Virtual thicknesses.
Greatest	(No. 10) 58,940	(No. 10) 45,300
Least	(No. 3a) 41,101	(No. 9) 34,200
Difference	17,839	11,100
Mean	46,682	39,100

8. Method of Calculating the Modulus of Stiffness.—The values of the modulus of stiffness are calculated by means of Equations 5 and 8, from data selected from those parts of Mr. Hart's record of experiments in which the deflection increased in the simple ratio of the load, or nearly so. The results are given in the annexed table (B). They are computed to four places of figures only. The difference between the greatest and least values is, as compared with the mean value, a little less than the corresponding difference for the modulus of rupture, as the following statement shows:

	Pounds on the square inch.
Greatest value (No. 2)	23,290,000
Least value (No. 11)	17,760,000
Difference	5,530,000
Mean value	20,420,000

Table (A) of Values of the Modulus of Rupture of Corrugated Iron, as Deduced from Mr. Hart's Experiments, with Virtual Thicknesses, Calculated from the Weights per Square Foot.

No. of experiment.	Modulus as calculated from measured thickness.	Measured thickness.	Virtual thickness.	Corrected modulus as calculated from virtual thickness.
	Pounds on the square inch.	inch.	inch.	Pounds on the square inch.
1	46,567	.029	.039	34,600
2	45,628	.035	.046	34,700
2*a*	50,900	.035	.046	38,700
3	41,663	.060	.069	36,250
3*a*	41,101	.060	.069	35,800
4	43,528	.060	.069	37,900
6	49,770	.100	.121	41,100
6*a*	52,376	.100	.121	43,300
6*b*	52,375	.100	.121	43,300
7	46,124	.100	.118	39,100
8	43,099	.095	.113	36,400
9	41,959	.095	.116	34,200
10	58,940	.100	.130	45,300
11	46,373	.115	.133	40,000
12	47,760	.150	.163	43,900
13	43,281	.150	.159	40,800

Mean from 16 experiments in pounds on the square inch 39,100
Mean in kilogrammes as the square metre 27,500,000
Mean in lineal feet of iron, weighing 480 pounds to the cubic foot 11,730
Mean in lineal metres of iron, weighing 7,690 kilogrammes to the cubic metre 3,575

Table (B) of the Values of Modulus of Stiffness of Corrugated Iron as Deduced from Mr. Hart's Experiments, with Virtual Thicknesses Calculated from the Weights per Square Foot.

Number of experiment.	Load pound.	Deflection inch.	Modulus of stiffness in pounds on the square inch.
1	262	1.00	18,710,000
2	314	0.64	23,290.000
4	384	0.34	20.830,000
6	599	0.46	20,830,000
7	600	0.46	22.280,000
8	258	1.36	19,760,000
9	314	1.26	19.170,000
10	1.332	0.44	21.350,000
11	1,251	0.58	17,760,000
12	1,334	1.02	19,540,000
13	1,098	0.80	21,080,000

Mean from 11 experiments in pounds on the square inch.................. 20,420,000
Mean in kilogrammes on the square metre 14,360,000,000
Mean in lineal feet of iron weighing 480 pounds to the cubic foot.......... 6,126,000
Mean in lineal metres of iron, weighing 7,690 kilogrammes to the cubic metre 1,867,000

9. Rules.—The following are the rules for practical purposes to which the results deduced from Mr. Hart's experiments in this communication lead:

I. Let b be the breadth of a sheet of corrugated iron, h the depth of the corrugations from ridge to furrow, and w the weight of an unit of the area of the sheet, as projected on a plane: to find the least probable *breaking moment*, M.

Calculate a virtual thickness, t', by the formula $t'=w \div k$; where k has the following values:

For w in pounds to the square foot, and t' in fractions of an inch; $k=40$.

For w in kilogrammes to the square metre, and t' in fractions of a metre; $k=7,690$.

Then

$$M=\frac{4}{15}fhbt'. \quad . \quad . \quad . \quad (9)$$

Least value of f;

For forces in pounds, dimensions in inches, and moments in inch-pounds. . 34,200

For forces in kilogrammes and dimensions in metres. . 24,000,000

II. Given, the intended least breaking moment M, the breadth b, and the depth of corrugation h, of a sheet of corrugated iron; to find the proper weight w of an unit of area;

$$w=kt'=\frac{15\,k\,M}{4fhb}. \quad . \quad . \quad (10)$$

Values of the factor

$$\frac{15k}{4f};$$

For w in pounds to the square foot, load in pounds, and dimensions in inches;

$$\frac{1}{228}=.00358;$$

For forces in kilogrammes and dimensions in metres;

$$\frac{1}{832}=.0012.$$

III. To find the *probable deflection* (v_1), *under half the breaking load*, of a given sheet of corrugated iron; l being the span.

$$v_1 = \frac{n''}{m'} \cdot \frac{f}{2\,\mathrm{E}} \cdot \frac{l^2}{4h}; \quad . \quad . \quad . \quad (11)$$

In which

$$\frac{f}{2\,\mathrm{E}} = .00096 = \frac{1}{1040}; \text{ and } \frac{n''}{m'}$$

has the following values:

Sheet loaded in middle of span $\frac{2}{3}$;

Sheet uniformly loaded, $\frac{5}{6}$.

The following later contribution to the "Bombay Builder" apparently concludes Mr. Hart's valuable paper on this subject:

Buckled plates—the invention and patent of R. Mallet, Esq., M. I. C. E.—are also an admirable substitute for wooden planking in the platforms of bridges, and have been extensively used in both England and India, the most notable instances being the Westminster and Soan bridges. They are square or rectangular plates domed in the centre, with a flat margin or "fillet" all round.

The versed sine or central rise is small, being about one twenty-fourth the greatest length of side. The fillet is from 2 inches to 6 inches wide, according to size of plate, etc. The material may be either iron or steel, and is protected from corrosion by a coating of some preservative composition, that recommended by the inventor being well-boiled coal-tar mixed with powdered caustic lime. In this the iron heated to black red (700° Fah.) is to be quenched. Steel plates will be half the weight of iron ones. Buckled plates possess certain advantages over corrugated sheets; for instance, they produce greater lateral stiffness in the platforms, and are said to be less perishable, owing to the fibre of the iron being less injured by the process of manufacture. They are lighter, and, of course, ought to be cheaper, because less material is used in an equal horizontal area of plate, the loss of plane surface in buckled plates being about one-seventieth of the original plate, while in corrugated sheets the loss is between one-fifth and one-fourth. On the other hand, to obtain full advantage of the strength of buckled plates, they must be supported all round. This leads to considerable expense in the arrangement of the girders and joists, and, except in iron structures, the requisite conditions cannot be readily obtained. Mr. Mallet states that the resistance of square buckled plates is directly as the thickness, and inversely as the clear bearing. That the resistance of a rectangular plate is nearly the same as that of a square plate whose side is equal the longer dimension of the oblong one, and that the longer edge should not be more than double the shorter. Also, that a plate fastened firmly on all its sides has double the strength of a plate merely supported all round; and if two opposite sides are wholly unsupported, its resistance is reduced as 8 to 5. In Rankine's "Civil Engineering," Section IV., Article 375, Division III., is the following formula for the resistance of a buckled plate.*

$$\mathrm{M} = \tfrac{4}{15} f_a\, l\, h\, t \quad . \quad . \quad . \quad . \quad .(20)$$

which is nearly the same as that given for corrugated iron. In this formula $f_a = 21{,}600$, l is the length of that section of plate at which the greatest bending moment is exerted; t, the thickness of the iron; h, the depth of curvature at the centre. If we suppose the plate to be supported at the ends only, the bending moment of the distributed loads is $= \frac{\mathrm{W}\,l}{8}$, hence the equation for the dimensions of the plate is

$$\frac{\mathrm{W}\,l}{8} = 5760\, l\, h\, t$$

$$\therefore \mathrm{W} = 46080\, h\, t \quad . \quad . \quad . \quad . \quad (21)$$

and if, as before, we take $w\,s = 200$, and since, as explained at equation 14, $\mathrm{W} = \mathrm{W}\ s\ \mathrm{L}\ \mathrm{B}$, therefore

$$t = \frac{200\,\mathrm{L\,B}}{46080\,h} = \frac{\mathrm{L\,B}}{230.4\,h} \quad . \quad . \quad . \quad (22)$$

If the factor of safety be 4, we have

$$t = \frac{\mathrm{L\,B}}{57.6\,h} \quad . \quad . \quad . \quad . \quad (23)$$

and if

$$h = \frac{l}{24} = \frac{\mathrm{L}}{2};$$

then

$$t = \frac{\mathrm{B}}{28.8} = .03473\ \mathrm{B} \quad . \quad . \quad . \quad (24)$$

* It is, I think, doubtful whether this formula will apply equally well for plates supported and fixed; but I have assumed that such is the case, basing my assumption on the treatment of the analogous case of beams fixed at both ends by the author himself.

For the square plates B = L, and the corresponding thicknesses of plates are as follows :—

L =	2,	2½,	3,	3½,	3,	4½,	5,	5½,	6;
t =	.069,	.087,	.104,	.122,	.139,	.156,	.174,	.191,	.208;
Nearest corresponding gauge..... =	16,	14,	12,	11,	9,	8,	7,	6,	5.

The cost of buckled plates, compared with corrugated sheets, may be obtained thus :

Let the gauge be assumed to be 12 deg. to 14 deg.; therefore, the weights per 100 square feet will be for 14 gauge =

$$\left(3.12 + \frac{3.12}{70}\right) 100 = 316.8 \text{ pounds} = .14 \text{ tons;}$$

12 gauge=

$$\left(4.38 + \frac{4.38}{70}\right) 100 = 444.3 \text{ pounds} = .2 \text{ tons.}$$

The cost per ton is £13 in England, plus £7 for freight and carriage to 100 miles from the coast, equal, say, Rs. 200; therefore, the cost of buckled plates would be from Rs. 28 to Rs. 40 per 100 square feet, or about one-fourth less than that of corrugated iron.

The relative cost of the three sorts of covering for platforms of road bridges may be summarized as follows:—Timber planks, Rs. 50 to Rs. 80 per 100 square feet; corrugated iron sheets, Rs. 40 to Rs. 50 per 100 square feet; iron buckled plates, Rs. 30 to Rs. 40 per 100 square feet, to each of which rates must be added the expense of fixing the material, such as spikes and carpenters' labor for the planking; rivets, bolts, and screws, with smiths' labor, for the iron.

The following table and information is extracted from a circular, by Mr. Mallet, "On Buckled Plates"

Table of Strength, Weight, and Cost.

Thickness of Plates.		Weight per square yard of buckled plates.	Weight of an equal surface of corrugated sheet of corresponding thickness.	Safe passive load uniformly diffused, per square yard, for 3-feet square plates.	Safe impulsive load uniformly diffused per square yard, for 3-feet square plates.	Cost per superficial yard of buckled plate at £13 per ton, in England.	Nearest number of square yards in one ton.	Notes, etc.
in.	B. W. G.	lbs.	lbs.	tons.	tons.	s. d.		
.048	18	17.3	20.7	0.27	0.20	2 2	129	Applicable to roofing and flooring.
.066	16	23.6	28.3	0.43	0.32	2 10	95	
.107	12	28.7	46.4	0.64	0.48	4 7	57	
$\frac{1}{8}$	Nearly 11	45.0	54.0	1.0	0.75	5 3	49	For lighter class of bridge and other floors.
$\frac{3}{16}$	Nearly 7	67.5	81.0	2.5	1.7	7 11	33	
$\frac{1}{4}$	Nearly 4	90.0	108.8	4.5	3.0	10 6	24	For heavier floors of railway and other bridges and viaducts.
$\frac{5}{16}$	Nearly 1	112.5	135.0	6.2	4.7	13 2	20	
$\frac{3}{8}$	......	135.0	162.0	9.0	6.8	15 8	16	Not as yet been found necessary in any structure.

"The size of buckled plates formed of one single rolled plate is only limited by the breadth to which sheet or plate iron can be rolled at market prices.

"The sizes that have been found most advantageous for the majority of purposes are plates of 3 feet and 4 feet square, or of those widths by the full length of the plate.

"Buckled plates may be united to each other, or to the frame of the structure they cover, by either lap or butt joints, and either by screw bolts, rivets, or wood screws to timber, and the joints made absolutely water-tight, when required, by riveting and chinking up, or by interposed strips of tape or of felt saturated in oil cement, or in tar or pitch ; or by strips of vulcanized india-rubber; or a thin layer of oil-putty.

"Economy is always consulted by supporting each plate all round. One pair of opposite fillets, resting on the girders or joists, and the other pair supported by an angle iron above, thus forming a lap plate.

"Three-feet square buckled plates are made of all the thicknesses of the above table, and 4 feet square plates of all the thicknesses except the first two, as also any intermediate thicknesses at ordinary rates; others at extra rates. All buckled plates are charged by weight. The maker's price includes royalty.

"Prices are regulated by the 'declared rates' of the Staffordshire iron market."

THE MANUFACTURE OF PIG IRON.

BLAST FURNACE IMPROVEMENT—TREATMENT OF ORES.

Utilization of Waste Gases.—Mr. Chas. Cochrane's paper on this subject, before the Mechanical Engineers' Association, states that with the increased capacity of the present large blast furnaces in the Cleveland district, the waste gas is so far impoverished, both in quantity and quality, that, in order to maintain a uniform supply of gas for the steam boilers and hot-blast stoves, it is of importance to utilize the whole of the gas given off from the furnace, by preventing the loss of gas hitherto occurring at the times of lowering the closing cone or bell for charging the materials at the top of the furnace. This loss amounts to fully 6 per cent. of the total quantity of gas evolved from the furnace; and the escape of the gas at the furnace mouth occasions an interruption in the supply for heating purposes, and a liability to explosion on restoring the supply at the boilers and stoves.

These objections have been obviated by the writer by a plan of doubly closing the furnace top, the ordinary closing bell and hopper being completely closed in by the addition of outer cover, containing flap doors, through which the charging materials are filled into the hopper. These doors are closed at the time of lowering the bell for dropping the charge into the furnace, so that the only escape of gas that can take place is a quantity equal to the capacity of the hopper at each time of lowering the bell, which is insignificant in amount. The plan has been in successful operation for 9 months at the Ormesby Iron Works, Middlesborough. The saving of fuel in the ovens and boilers by having a continuous flow of gas, Mr. Cochrane estimated as about 9 tons a week per furnace, which, in the year round, represented a total saving of £150 to £160. The cost of the apparatus was £200.

Increased Size of Furnaces.—The second portion of Mr. Cochrane's paper had reference to the increased capacity of a furnace lately erected by him at the same works. The original furnace was 35 feet high and 16 feet diameter in the boshes, of a total capacity of about 7,000 cubic feet; it worked to a yield of rather over 30 cwt. of coke per ton of iron produced. The newly-erected furnace is 76 feet high and 23 feet diameter in the boshes, and of a total capacity of 20,624 cubic feet. It works to a yield of about 26 cwt. of coke per ton of iron produced, thus showing a saving of between 4 cwt. and 5 cwt. of coke per ton of iron. The Cleveland ironstone produces about 40 per cent. of iron. The author gave some interesting and detailed calculations, showing that the theoretical saving to be obtained by increasing the capacity of a furnace and thus making the materials in the upper portion act as a regenerator to take up the caloric from the incandescent materials below, was fully borne out in practical working. Following the line of these calculations, he estimated that a furnace, with 60,000 cubic feet of capacity and 113 feet high, should reduce the consumption of fuel to something like $7\frac{1}{2}$ cwt. per ton of iron produced. The extreme theoretical limit of economy, when the escaping gas would be reduced to the temperature of the external atmosphere, would be reached by increasing the capacity of the furnace to about three times that of the present large furnaces in the Cleveland districts.

In the discussion of the paper it appeared that one of the Ferry Hill Furnaces, Durham, was working with 16 cwt. of coke per ton. This was partly due to the height, 105 feet (25 to 26 feet boshes), and partly to the excellent hot blast stove used; the ore yield 57 per cent. against 40 per cent. in the Cleveland district. As to high furnaces, Professor Tunner states in a report on the Paris Exposition, that the results can only be considered important locally; such hard coke and such coarse aggregates of ironstones as are worked in the Cleveland district are not to be found again soon, nor everywhere. Whether or not the American anthracite coal will sustain such a burden, has not been determined; many authorities think it will. It is of the utmost importance to the Bessemer manufacture, at least, that the experiment be tried.

THE HOT BLAST.—An acknowledged progress has been made, says Professor Tunner, and is still becoming extended in application, in the heating of the blast to the highest possible degree. Even the coke-consuming furnaces, which are supplied with a cast-iron blast-heating apparatus, blow with air heated to 300° or 360° C.; but the blast-heating apparatus constructed upon the principle of Siemens' regenerator, of which there is also one in use at Friedrich Wilhelmshütte, near Siegburg in Westphalia, affords a still higher temperature, and would be more generally employed if its maintenance had not been found, so far, subject to so many interruptions and repairs, arising mainly from the interior lodgments of dust upon the brick heaters. With the high temperature of the blast is not only connected an enlargement of the furnace at the bottom, but at the same time a narrowing of the furnace mouth, and also with the complete disappearance of the boshes, whence has been attained the further advantage of a regular descent of the charge in work. The English and Scotch furnaces are distinguished in that way before all others.

GORMANS' GAS FURNACE.—Experiments in progress at the Gartsherrie Works are thus described: The furnace has two side channels or pockets extending vertically from the level of the tuyeres up to the charging platform, and forming special shafts or compartments for charging the coal into, while the ore, either all by itself, or mixed with an additional charge of coal, is brought into the blast furnace in the usual way; the furnace proper being open at the top. It is the intention to keep the coal separate from the ironstone until the former has been converted into coke, and the latter has arrived close above the tuyeres. At that place the side pockets which contain the charge of fuel open into the main stack of the furnace, and there the mixture between coke and ore takes place. The coal chambers are closed at the top, and the gas from the coal can be utilized as fuel or led into the main stack of the furnace for affecting the reduction of ore. In this manner it is expected that the ironstone will be reduced by the action of the ascending current of gas alone, and arrive at the openings of the side pockets in the state of spongy iron, or reduced metallic iron, which requires nothing but carburization for melting and running down into the hearth. The short space over the tuyeres should then act as a cupola for melting the spongy iron by means of the coke brought down into that space from the side pockets of the furnace.

"Engineering" says of this scheme:—The problem of separating the solid coal from the charge, and of reducing the ironstone by the action of gases alone, has never been brought to a satisfactory solution, however often and carefully experimented with. In the blast furnace itself the ore is in direct contact with solid carbon. In the higher zones of the furnace, where reduction takes place, an atmosphere of carbonic acid and of oxide of carbon exists at a temperature scarcely exceeding red heat, but the presence of coal and of oxygen from the iron ore seem to keep that atmosphere in a state of continuous charge between the higher and lower oxide of carbon. All particles of carbonic acid when in contact with coal become reduced to carbonic oxide, and the carbonic oxide in contact with the ore become carbonic acid again. This state of mobility or virtual motion of atoms seems to be requisite for the work of reduction, and it appears that an atmosphere of carbonic oxide alone is not capable of effecting the reduction of ironstone at that low temperature. It is clear, indeed, that the temperature maintained in the zone lowreduction is due to the presence of the solid carbon, since the process of converting carbonic acid into carbonic oxide by bringing it into combination with another atom of carbon is a cooling process absorbing fully one-third of the total heat which that carbon would evolve when completely burned in the open air. If we attempt, therefore, to effect the reduction of iron ores by a stream of carbonic oxide gas alone, we lose this cooling agency, we effect the combustion of the carbonic oxide gas at the expenses of the oxygen from the ore, and we thereby raise the temperature of the zone. The ore under these circumstances will become heated more and more until it will commence to melt without reduction. The furnace if kept hot enough at the tuyeres will then produce nothing but liquid oxides, silicates, etc., in the form of slag, which is simply the ore melted but not reduced. To obtain such a result, however, a great supply of heat from an exterior source is necessary, since there are zones below that zone of reduction just referred to, which require heat in order to keep the molten ironstone liquid at the time when it no longer gives off oxygen to the gas in contact with it.

In a common blast furnace where no such special source of heat is available, the probable result of a separation of the coal from the ore, would be to set the whole furnace fast in a few minutes. If, on the other hand, a regenerative gas furnace, or an air-furnace fired externally, is employed for that purpose, and connected with a stack or hopper for reducing the ore by ascending gas, a continuous and very profuse supply of liquid slag can be relied on, as the result of this mode of reducing iron ores by an atmosphere or current of carbonic oxide gas.

Carbonizing Ores.—A considerable economy in the reduction of iron ores is obtained at the Almond Ironworks, in England, by previously carbonizing or coking the ores, instead of merely calcining them. The process—Aitkens'—is largely illustrated in the "Practical Mechanics' Journal" of October last. It is stated that the carbon in the ores is retained, to serve for fuel in their reduction. Almost any apparatus suitable for coking coal may be employed.

Purification of Ores.—On this subject "Engineering" says: The rationale of the process of washing iron ores after calcination is the following:—An iron ore contaminated with pyrites, when submitted to calcination, under the free access and influence of the air, takes up a certain quantity of oxygen, and by that process the pyrites and other similar combinations of sulphur and iron become converted into sulphates of iron, which are soluble in water. If then the ore is washed with a large quantity of water and for a considerable length of time, all those soluble salts, and with them the component sulphur, will be removed. The purification from sulphur is most effectively attained by washing at the Kladno Ironworks, in Bohemia, where forge iron for puddling is the staple article, and at the Ironworks of Maria Zell, in Styria, producing foundry and Bessemer pig iron.

A new method of purifying iron ores now under experiment was patented by Mr. Thomas Rowan, of Glasgow, and consists in calcination and subsequent washing, only the calcination in this instance is not a mere oxidizing process as now practised, but the ore is mixed with chorides, such as common salt or chloride of manganese, and calcined in contact with these substances, the effect being to convert many of the substances contained in the ore into chlorides. The idea of removing phosphorus from iron by the action of chlorine was originated by Dr. Crace Calvert, of Manchester, more than twenty years ago, but it appears that Dr. Calvert expected a gaseous combination of phosphorus and chlorine to be formed and passed off as a vapour either from the blast furnace or calcining kiln. Mr. Rowan's researches seem to show that none of the volatile combinations of chlorine and phosphorus are formed during such a calcination, but that a combination is formed which is soluble in water, and can be extracted from the ore by washing after the calcination is completed. The effect of washing the ore after this chloridizing calcination is the removal of the sulphate of soda and of the clorides of phosphorus formed in that process.

It has been proposed, at one of the great ironworks in the Cleveland district, to effect this calcination by charging the ironstone mixed with salt into the calcining kilns now in use, but this is not a suitable mode of working on a large scale. The time for calcination, and particularly that for washing, should be ample, and much greater than can be allowed in the calcining kiln. The calcination should be carried on close to the mines in very large heaps covered at the top and connected at the bottom with flues which lead into a chimney. The salt mixed with the ore, or, still better, dissolved in water and sent into the calcining heap in the form of small jets or streams of brine, would act upon the mass for any desirable length of time. The whole calcining heap should, after being burnt out, be immersed with water, or be percolated by a large stream or body of water for several weeks. After this the ore may be sent to the smelting works, and the calcining kilns there will play the part of evaporators only. They will dry the ore and heat it to some extent previous to its being charged into the blast furnace.

SETTING OUT RAILWAY CURVES.

AN EASY CURVE FOR CONNECTING RAILWAY TANGENTS, WITH TABLES ADAPTED TO SETTING-OUT BY THEODOLITE.

By W. Airy, from "The Engineer."

It will, no doubt, be admitted by all who have had experience in the permanent setting-out of railways, that there is no method so rapid or accurate of setting-out curves as by theodolite. For preliminary work, indeed, it is possible to use other methods—the off-set method, for instance—with great success; but when a railway is formed, and the question is one of laying the rails to true curve, the theodolite method is the only reliable plan in practice. When, therefore, the writer of the present paper took the subject in hand, he made it a first consideration that no curve should be adopted which had not the property of being readily set out by theodolite; and the character of the curve and the form of the tables have all been suited to the above condition.

With regard to the necessity for such a curve, the writer takes that for granted. It is notorious that sharp curves are systematically "eased off" at the springing, in order to lessen the lateral shock to a train coming upon them off a piece of straight, but this very remedy may easily prove harmful, except the "easing off" is carried a long way up the curve, for it is clear that a curve cannot be flattened at one point without being rendered sharper at some other point; and if, as mostly happens, the curve is flattened at the springing without a careful adjustment of the curve for a long distance up, then a dangerous kink is left in the curve; and the writer has seen engines run off the line for this very reason. Various attempts have been made to ease off curves on a system; the curve of sines and the curve of adjustment have both been applied to the purpose; but neither of these curves is adapted to setting-out by theodolite, and the inconvenience of setting-out curves with poles on a railway nearly finished—and it is at that time that it has to be done—when the work is going on, and the way is much blocked with materials of all sorts, is almost intolerable, and renders any method of this kind quite impracticable.

The curve which is adopted in the present paper, together with the tables, was communicated to the writer by the Astronomer Royal; for the application of the curve nothing is assumed beyond the ordinary data, viz., two straight lines and the angle they include; the appended tables will then give all the elements required for laying down the curve on the ground, and for computing its length, etc., as may be necessary.

The curve is the cubical parabola whose equation is

$$y = \frac{x^3}{a^2}.$$

The chief advantage of this curve is that it hugs the tangent very closely for a long distance after leaving it, and thus the change of curvature is at first very gradual—which is the object in view. It has also the advantage of being the simplest curve of its class, and, by reason of the high powers involved in the expansions which occur when dealing with the properties of the curve, very close approximations are arrived at in very few terms of the series.

The denominator a^2, in the equation above given, as an arbitrary constant; and its value assumed for the formation of the present tables, $a^2 = 400$, has been chosen from the following considerations. Among the properties of the curve, it will be found that the radius of curvature decreases from infinity at the commencement of the curve, till it attains a minimum value at a point for which,

$$x = \frac{a}{\sqrt[4]{45}}.$$

Now, it is assumed that in setting-out railway curves, the ordinary unit of measurement will be the chain, and that, in general, the minimum radius of curvature allowed will be 10 or 11 chains; these, then, have been selected as conditions proper for determining the form of the curve, and the value of a^2, which has been adopted, will be found to produce a minimum radius of curvature = 11.3. It must, however, be observed that the foregoing assumptions merely fix the general shape of the curve, and do not in any way restrict the use of the curve to the precise conditions which were assumed in order to determine a suitable value for the constant; it will be at the option of the engineer to fix the minimum radius of curvature which he will admit, and the tables can then be used at once to set out the curve, so as to have that minimum radius of curvature, with this provision, that if the minimum radius of curvature which he adopts be other than 11.3 chains, he must work with a different length than the chain as unit. The method of fixing the unit and applying the tables will be seen in the examples below.

The tables are adapted to the method ordinarily pursued in setting-out circular curves; the successive unit lengths are chained along the curve, and the angles set off from the tangent by means of the theodolite. In ranging the curve, since the minimum radius of curvature is reached at a certain definite distance, in terms of the unit, from the tangent point, it may happen that this distance is less than half the length of the curve; in this case the curve is supposed continued with a circular curve of the said minimum radius until the half curve is completed, and the other half of the curve is ranged in the same manner from the other tangent point. There is no calculation involved in the above arrangement, but the necessary angles are taken out of the tables continuously and without interruption.

It may be well to describe the process to be followed in a given case. The first thing is to determine what shall be the sharpest curvature allowed, as this will fix the unit of measurement; the next thing will be with the known angular change of direction (this will be the same as the exterior angle between the tangents), to take out of Table I. the distance of the ends of the curve from the intersection of the tangents, in units of the length already determined; and thirdly, the theodolite must be planted at one of these points, and the half-curve ranged in successive unit lengths by the angles given in Table II.; the same must be done for the other point, and the curve is ranged.

Thus, for example, let the angular change of direction be 50 deg. and let it be determined to fix 15 chains as the minimum radius of curvature. From Table I. it appears that from an angle of 50 deg. the length of the semi-curve is 8.052. Also from Table II., it appears that at a distance along the curve of 8.0, the radius of curvature is 11.4. If, therefore, it be intended that this minimum radius of curvature shall represent 15 chains, the unit of length must be taken at $\frac{15}{11.4}=1.31$ chains; in other words, the unit must be a chain of 131 links.

Referring back to Table I., it appears that for angle 50 deg., the distance of the theodolite station from the intersection of the tangents is 8.456, or, using the proper unit, is $8.456 \times 1.31 = 11.08$ chains; and if this distance be measured along both tangents it will fix the two ends of the curve.

The theodolite may now be planted at one of these points, and the half curve ranged by means of the angles given in Table II., using throughout a length of 131 links as the unit. When half the curve is ranged, the theodolite must be shifted to the other end of the curve for ranging the other half.

In the above example it has been necessary to make use of a unit adapted to the conditions; but should the conditions be altered, so that the minimum radius of curvature, as found in the tables, and due to the angular change of direction, be not less than 15 chains, then the ordinary chain of 100 links can be used as unit. Thus, let the angular change of direction be 15 deg., then the tabular semi-length of the curve is 4.197, and the tabular radius of curvature due to this semi-length is nearly 16; consequently, the chain of 100 links may be assumed as the unit without fear of transgressing the fixed minimum radius of curvature, 15 chains.

With the foregoing explanation we may proceed at once to the tables:

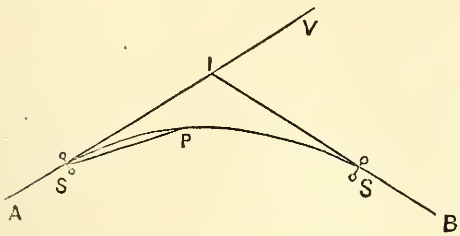
Let A I, B I, be the two tangent lines which are to be united by the curve, so that V I S, the angular change of direction, is a known angle; then, for the complete setting-out of the curve, we require to know the following elements:

1. The equal distances I T, I S, which define the theodolite stations, T and S.

2. The length of the curve.

3. The theodolite angle P T I, for successive points defined by the meas-

ure of successive unit lengths on the curve.



4. The radius of curvature for several points along the curve.

To supply these elements the two following tables have been computed :

TABLE I.—*Argument: The angular change of direction; giving the distance of theodolite station from intersection of tangents, and length of semi-curve.*

Angular change of direction.	Distance of theodolite station from intersection of tangents.	Length of semi-curve	Angular change of direction.	Distance of theodolite station from intersection of tangents.	Length of semi-curve.
deg.	Chains.	Chains.	deg.	Chains.	Chains.
1	1·076	1·076	52	8·704	8·250
2	1·525	1·525	53	8·829	8·349
3	1·868	1·868	54	8·955	8·449
4	2·158	2·157	55	9·082	8·548
5	2·414	2·413	56	9·211	8·647
6	2·646	2·645	57	9·340	8·746
7	2·860	2·857	58	9·471	8·846
8	3·058	3·055	59	9·603	8·945
9	3·245	3·241	60	9·737	9·044
10	3·424	3·417	61	9·872	9·143
11	3·594	3·586	62	10·008	9·243
12	3·753	3·748	63	10·146	9·342
13	3·914	3·902	64	10·285	9·441
14	4·066	4·052	65	10·426	9·540
15	4·214	4·197	66	10·568	9·640
16	4·357	4·337	67	10·712	9·739
17	4·497	4·475	68	10·858	9·838
18	4·633	4·607	69	11·005	9·937
19	4·767	4·736	70	11·154	10·037
20	4·899	4·864	71	11·305	10·136
21	5·028	4·988	72	11·458	10·235
22	5·155	5·110	73	11·612	10·334
23	5·230	5·229	74	11·769	10·434
24	5·403	5·347	75	11·928	10·533
25	5·596	5·463	76	12.089	10·632
26	5·647	5·577	77	12·252	10·731
27	5·766	5·689	78	12·418	10·831
28	5·885	5·801	79	12·586	10·930
29	6·003	5·911	80	12·756	11·029
30	6·120	6·019	81	12·929	11·128
31	6·237	6·127	82	13·104	11·228
32	6·353	6·233	83	13·282	11·327
33	6·468	6·329	84	13·463	11·426
34	6·584	6·444	85	13·647	11·525
35	6·699	6·547	86	13·833	11·625
36	6·813	6·650	87	14·023	11·724
37	6·9 8	6·753	88	14·216	11·823
38	7·043	6·855	89	14·412	11·922
39	7·159	6·956	90	14·612	12·022
40	7·274	7·057	91	14·815	12·121
41	7·389	7·157	92	15·022	12·220
42	7·505	7·257	93	15·232	12·319
43	7·622	7·357	94	15·446	12·419
44	7·739	7·457	95	15·665	12·518
45	7·857	7·556	96	15·887	12·617
46	7·975	7·656	97	16·114	12·716
47	8·094	7·755	98	16·346	12·816
48	8·214	7·854	99	16·582	12·915
49	8·335	7·953	100	16·823	13·014
50	8·456	8·052	101	17·070	13·113
51	8·579	8·151	102	17·321	13·213

TABLE II.—*Argument: Measure from Theodolite Station along the Curve: giving Angle at the Theodolite, and Radius of Curvature.*

Measure from theodolite station along the curve.	Angle at the theodolite.			Radius of curvature.
Chains.	deg.	min.	sec.	Chains.
0·25		0	30	
0·50		2	10	
0·75		4	50	
1·00		8	40	66.7
1·25		13	30	
1·50		19	20	
1·75		26	20	
2·00		34	20	33·4
2·25		43	30	
2·50		53	40	
2·75	1	5	0	
3·00	1	17	20	22·4
3·25	1	30	40	
3·50	1	47	30	
3·75	2	0	30	
4·00	2	17	0	17·0
4·25	2	34	30	
4·50	2	53	10	
4·75	3	12	40	
5·00	3	33	10	14·0
5·25	3	54	0	
5·50	4	17	10	
5·75	4	40	20	
6·00	5	4	20	12.3
6·25	5	29	20	
6·50	5	55	0	
6·75	6	21	30	
7·00	6	48	50	11·4
7·25	7	16	40	
7·50	7	45	10	
7.75	8	14	20	
8.00	8	44	0	11·4
8·25	9	14	0	
8·50	9	44	40	
8·75	10	15	30	
9·00	10	47	0	11·4
9·25	11	18	30	
9·50	11	50	30	
9·75	12	22	40	
10·00	12	55	20	11·4
10·25	13	28	0	
10·50	14	1	0	
10·75	14	34	10	
11·00	15	7	30	11·4
11·25	15	41	10	
11·50	16	14	50	
11·75	16	48	50	
12·00	17	22	50	11·4
12·25	17	57	0	
12·50	18	31	20	
12·75	19	5	40	
13·00	19	50	20	11·4

PILES placed in the Rhine by the Romans, nearly 2,000 years ago, have been found to be entirely sound when removed within the present century.

CHIMNEYS.

The chimney of the West Cumberland Hæmatite Iron Works is deemed by Professor Rankine worthy of an extended paper before the Institute of Civil Engineers in Scotland, not because it is new or extraordinary in design, but because it is a successful example of the application of correct principles and good workmanship. We extract the following particulars :

	Feet.
Height above the ground line..........	250
Depth of foundation below the ground line (including a layer of concrete 3 ft. deep)	17

	Ft.	in.
Inside diameter at top of cone........	13	0
" " at 2 ft. above bottom of cone..............	21	10
" " of basement..........	18	10
" " of archways for flues..	7	6
Outside diameter at top of cone	15	3
" " at 2 ft. above bottom of cone.............	25	7

Outside dimensions of square basement.................. 30 ft. × 30 ft.

	Ft. in.		Ft. in.
Outside dimensions of foundation course......................	31 6	×	21 6
Outside dimensions of concrete foundation..................	34 6	×	34 6

The change from the square to the octagonal shape in the basement is made gradually by stepping the brickwork at the corners. A straight batter was used in preference to the theoretically correct curved batter, because the former could be tested by the eye.

The duty of the chimney is to carry off the gaseous products from 4 blast furnaces and various stoves and boilers—say from $10\frac{1}{4}$ tons of fuel per hour.

It had previously been ascertained, that in order that a round chimney in this windy region may be sufficiently stable, its weight should be such that a pressure of wind of about 55 lb. per square foot of a plane surface directly facing the wind, or $27\frac{1}{2}$ lb. per square foot of the plane projection of a cylindrical surface—that is to say, a pressure equivalent to the weight of a layer of brickwork 3 in. deep, and of an area equal to the vertical section of a round chimney—shall not cause the resultant pressure of any bed-joint to deviate from the axis of the chimney by more than one-quarter of the outside diameter at that joint. By calculating according to that principle the thicknesses of brickwork in the cone were determined to be as follows :

Uppermost	80 ft.	of height..	$1\frac{1}{2}$ brick.
Next	80 ft.	" ..	2 bricks.
"	88 ft.	" ..	$2\frac{1}{2}$ "

Lowest 2 ft., increasing by steps from $2\frac{1}{2}$ to 4 bricks, in order to spread the pressure on the basement. The bed-joint of least stability is 2 ft. above the ground line. The thickness of the arching in the openings for flues is three bricks. The following are the intensities of the mean pressures due to the load on different bed-joints :

	Tons on the Square foot.
At 2 ft. above the ground line..........	8
In basement at the springing of the arches	3
On the upper surface of the concrete...	2
On the ground below.................	1.6

The thickness of brickwork already stated, include the fire-brick lining, whose thicknesses are as follows:—In the uppermost 160 ft. of the cone, half brick; in the lower part of the cone, the basement, and the flue archways, one brick. The fire-brick lining is bonded with the common brickwork in the ordinary way—the fire-bricks are laid in the fire-clay and the common bricks in mortar. The reasons for adopting this mode of construction in preference to an internal fire-brick chimney are, 1st, the fire-bricks contribute to the stability of the chimney; 2d, unless the internal chimney is carried up to the top of the outer cone, there is a risk of damage through the explosion of inflammable gaseous mixtures in the space between; and, 3d, under the same circumstances there is a risk of the cracking of the outer cone at and near the upper end of the inner cone through unequal heating at that place.

Vertical cracks in a chimney are the more dangerous the higher the level at which they occur, because the safety of the higher part of a chimney depends more on cohesion and less on weight than that of the lower part. When such cracks take place near the ground, they are of little or no consequence.

The basement is paved inside with 6 in. of fire-brick, resting on 6 in. of common brick, which rests on the concrete.

The ordinary brickwork is built in English bond; in the basement there is one course of headers to every two courses of stretchers; on the cone, one course of headers to every three courses of stretchers. Strips of No. 15 hoop iron, tarred and sanded, are laid in the bed-joints of the common brickwork cone at intervals of 4 ft. in height, with their ends turned down into the side joints. In the concrete foundation, the basement, and a small part of the cone, the mortar was made of hydraulic lime; the mortar for the rest was made of a pure lime rendered artificially hydraulic by a mixture of iron scale in the following proportions :

Lime........................	2 measures.
Scale........................	1 "
Sand........................	5 "

The principal constituents of the iron scale are probably silica and protoxide of iron, but its action upon lime, and the nature of the artificial cement which it forms, have not hitherto been investigated by chemists.

On the top of the chimney is a pitch-coated, cast-iron curb, 1 in. thick, coming down 3 in. on the outside and inside. The lightning conductor is a copper wire rope, about $\frac{3}{4}$ in. diameter. It terminates in a covered drain, in which there is always a sufficient run of water.

In the construction of the internal scaffolding care was taken that the horizontal beams should be supported wholly by the brickwork, and not by the upright posts; for great danger has been known to arise from the brickwork coming to bear upon the ends of the needles, and through them on the posts, owing to the settlement of the lower part of the chimney.

In order that the concrete foundation might have time to harden before being subjected to a heavy load, it was made by the Iron Company themselves before the contract for the chimney was let; for it is known that intense pressure tends to retard the hardening of concrete. The progress of the building was restricted by the specification to a rate not exceeding 6 ft. of vertical height per day.

The work was executed by Messrs. Wm. Wilson & Son, Glasgow. The estimated cost was £1,672; the actual cost, including designing and superintendence, £1,560; being at the rate of almost exactly fourpence per cubic foot of the whole space occupied by the building, which is 94,000 cubic feet nearly.

According to the latest account, the temperature inside the chimney, when doing about three-fourths of its full duty, is 490° Fah.; and the pressure of the draught is $1\frac{7}{8}$ in. of water, which agrees to a very small fraction with the pressure as deduced theoretically from the temperature and the height of the chimney.

The dimensions and stability of the chimney which has just been described are nearly the same with those of the second highest chimney at St. Rollox Chemical Works, built about ten years previously, except that in the older chimney the joint of least stability is 100 ft. above the ground.

In the great St. Rollox chimney, $445\frac{1}{2}$ ft. high from foundation to top, the greatest pressure of wind which can safely be borne is almost exactly the same. The bed-joint of least stability is 210 ft. above the ground. In the great Port-Dundas chimney, 468 ft. high from foundation to top, the bed-joint of least stability is 200 ft. above the ground; and the greatest safe pressure of wind is 67 lb. per square foot of a plane surface, or $33\frac{1}{2}$ lb. per square foot of plane projection of a cylindrical surface, so that there it may be considered that there is an excess of stability.

One of the richest and most ornamental of modern chimneys is connected with the new India mill, Dorwen, Lancashire. The total height of the chimney shaft from the bottom of the foundations to the top of the iron cresting is $310\frac{1}{2}$ ft., and from the ground line 300 ft. The base is of solid ashlar, 29 ft. square at ground line, and 42 ft. high. The stone cornice to the base is 35 ft. long on each of the four sides. The shaft itself is built with red, white, and black bricks, with sand gritstone dressings, and is 24 ft. square, and built perfectly plumb. The walls are 3 ft. thick at top of stone base, reduced by "offsets" on the inside to 23 in. at the commencement of main cornice, which is 255 ft. above the ground. Many of the stones used in this cornice weighed as much as 5 tons each, and were hoisted by steam power. The balusters surmounting this feature are of cast-iron, as also are portions of the 4 vases at the corners. The crown mould of the cornice at the top of the shaft projects more than three times as far over the wall as it rests on it, and was kept in its place by iron cramps until the cast-iron cresting was fixed upon it. This cresting contains about 20 tons of metal, and is composed of more than 300 castings. There is no bolting nor any particle of wrought-iron in this portion of the work, the parts being kept together by slots and lugs. The whole weight of this cresting stands upon the brickwork, and keeps the upper stone cornice firmly in position. There is an interior and totally independent shaft, 180 ft. high, to prevent the great heat from the boiler furnaces subjecting the wall of the outer and main shaft to unequal expansion and contraction.

MODERN ARCHITECTURE.

THE OFFICE OF ART IN ENGINEERING.

It may be stated, as a general rule, that whatever in construction—in engineering construction even—is true and suitable and proportioned to strains and service, is also beautiful; or if this statement is too broad, it will not be denied that those structures in which material is utilized and power is applied to the best advantage, are the most beautiful and pleasing. This is as true of a connecting rod as of a cathedral. The art element should therefore be considered in engineering, on professional grounds as well as in the general interests of civilization and refinement. In architectural construction, and in all great or conspicuous engineering works, the want of farther ornamentation and balance of parts may often appear after the strains and functions are all provided for, but it will nevertheless be found, when "artistic effect" is *stuck on* by an afterthought, that both truth and taste have been violated. The artistic element must be associated with the design from the beginning. The following extracts from an article entitled "Modern Architecture—the Philosophy of Failure and the Secret of Success," are from "The Building News":

It will be admitted by intelligent observers of all schools that modern architecture regarded from an art point of view is not a success. We have huge edifices, triumphs of engineering skill, imposing piles of building resplendent with tropies of the stone-carver's craft, and magnificent erections of iron and glass, marvellous as specimens of metalwork, and gorgeous in their effect. Nevertheless we have no distinctive and satisfactory style, no precise principle of construction, no characteristic method of ornamentation, and no practical power of realizing that idea of *beauty* which hovers in thought before the mind of every intelligent designer.

It may seem but the repetition of a hackneyed truism to assert that the *true* and the *beautiful* are inseparable. Yet if we are not greatly deceived it is because in modern architecture these two qualities are regarded and treated as separable that the practice of art is a failure. As a matter of fact the attainment of beauty is proposed as an object altogether apart from the consideration of truth.

The architect who designs his building on a purely utilitarian principle, trusting to his ingenuity to make it beautiful by a subsequent process of ornamentation, is practising an æsthetic fraud. His edifice is not beautiful in itself, he is conscious of its defect; hence he labors to give it a meretricious aspect by means of ornament. Is it wonderful if he fails? Again, the designer who distorts the constructional parts of his work with the aim to realize something of beauty is no less untruthful, inasmuch as the ornamental feature, the façade or the tower he contrives to produce, are not necessary—they form no integral part of the utile edifice. The public eye quickly detects the artifice.

In illustration of these supposed classes of work, and in proof that they are not imaginative, it is only necessary to instance the numberless hotels, stations, warehouses, and public buildings scattered throughout the country which in themselves are ugly, but to the perverted vision of a vitiated taste are made tolerable by an incrustation of cornices, carved friezes, statuettes, intricate metalwork and elaborate ornament. These are examples of buildings erected without a thought of beauty and beautified afterwards. The class of works which are untruthful in their form, and ape beauty rather than possess it, may be illustrated by the 12 or 14-roomed houses fashioned like castles, the insurance offices and banks built to resemble edifices of great civic importance. The cloistered bath and wash houses, the club houses and reading rooms, like Greek or Roman temples, the divans like ducal palaces, and the parish churches in town and country constructed as cathedrals—all these things are *deceptive,* and it is because they transgress the principle of truth and regard the attainment of beauty as an object to be gained apart from truth, and even in violation of its immutable and universal laws, that they are failures.

Among the examples of works designed in neglect of the principle of truth, Silesbury Cathedral is mentioned; its chief defect is weakness. The violation of engineering truth at once impairs the artistic effect.

It is a task of great difficulty to define the precise conditions of architectural truth. On the first blush of the matter it is self-evident that there must be purity of intention in the design. If a man sets out with the purpose of building a barn, it must not be a Swiss villa or a Chinese joss-house that he plans—it must be a barn pure and simple. The practical error takes its rise in the false notion that certain objects are more respectable and pleasing than others, and, falling into the vicious practice of flattery, the architect deems it more complimentary to the feelings of his client or considerate to public taste to make his barn look like something very charming, light, and graceful. Now, truth would forbid all such misrepresentation of fact, and would interdict all meretricious ornament. It would require a grandeur, and a style and degree of ornamentation, befitting the nature of the building and the purpose to which it was to be applied, but it would not allow the enrichment of a plain mass with a view to raise it to the pitch of beauty supposed to be possessed by a building of more elaborate figure. This was the principle on which the designers of the best and purest epochs in the history of art acted. The works which have been preserved for us from the thirteenth century are eminently *truthful* in their intention. They tell the story of their use without disguise or prevarication. They do not seek to appear more noble or higher in the scale of beauty than they are placed as respects the arrangement, configuration, and balance of the masses of which they are composed. The ornament is never excessive, it never belongs to a class of building more elevated or elaborate than that to which it is applied; it never suggests the idea that the designer aimed to make his work look *enriched* or beautified. Simplicity and truth are characteristics of a style which all accept as thoroughly honest and pre-eminently respectable.

The error into which the Gothic revivalists have fallen is that they have attempted to produce the *form* of mediæval work but neglected the *spirit*. Now it must be evident that much of the architecture which we admire in its place, amid the associations of the thirteenth century, would be anachronic, however skilfully reproduced in the nineteenth century. What we want is a revival of the old spirit of manly outspoken honesty and the love of truth which animated the old art-architects. Special developments of art are inseparably connected with conditions of time, place, and circumstance. We cannot live, and dress, or build as they did who lived in the thirteenth century, but we can subject ourselves to the same pure and simple influences of truth which swayed their minds.

MANAGEMENT OF SMALL TUBULAR BOILERS.

Under the head of management of portable engine boilers, a correspondent of "The Engineer" gives some useful information on this subject. The boilers referred to are of the locomotive type. The cylinders are usually at the fire-box end, and the exhaust pipe passes inside or outside the barrel to the blast nozzle. The feed-water enters the boiler in some cases through the tube plate of the barrel, but more generally through the underside of the barrel near its front end.

For washing out the boiler there are generally 7 mud holes, 1 at each corner round the bottom of the fire-box, and 1 at the bottom of the smoke-box tube plate; the number and position of these holes are very inadequate to the thorough cleansing of the boiler from the dirt and impurities which enter with the feed-water, and which, if not constantly and easily removed, soon fill it with incrustation; the parts that suffer most from this great enemy to all boilers are the water spaces and stays around the fire-box, and among the tubes in the neighborhood of the feed-pump, the greatest amount of incrustation being formed in the front water space of the fire-box where no mud holes exist. To remove the deposit from this space, the best plan is to cut a mud hole in the outer plate at a short distance below the tubes, and as near the middle of the plate as practicable; by this means the dirt which drops down from the tubes is easily removed. One or two additional mud holes arranged in a higher position round the fire-box shell, would also prove of great assistance in keeping the stays free from corrosion.

In the neighborhood of the feed-pump, and immediately opposite the orifice in the boiler, incrustation is rapidly formed among the tubes; so much so, that the spaces between them, and even the feed orifice itself, become sometimes completely choked with dirt. The consequence is, that the water delivered by the pump not having free admission to the boiler, causes shortness of water and constant breakage of the working gear. For cleaning this part of the boiler, a plan I have generally adopted with success is to fix a 2-inch gun-metal plug at the side of the smoke-box tube plate and clear of the tubes, directly in a line with the feed orifice; by occasionally removing this plug and introducing a rod, the incrustation which forms round the feed orifice is broken up and falls to the bottom of the barrel, whence it is removed through the existing mud hole. It is also well to fix a half-inch plug in the side of the feed-pump valve box, immediately opposite the delivery orifice in the side of the boiler. A rod introduced through this hole will always keep the delivery pipe free from corrosion. To still farther prevent the accumulation of dirt, it will be found a good plan to draw a few tubes periodically—say, half-a-dozen on the feed side; by this means the incrustation formed among them can be quickly and completely removed. A good boiler-maker will draw these tubes without damaging them, and they can then be put in again; but even if 1 or 2 of them fail and require renewing, the expense of the new tubes is soon saved by a decrease in the consumption of fuel consequent upon a clean barrel. I have generally found it to be further advisable at the end of 12 months, if the boiler has been pretty regularly worked during the time, to draw all the tubes, and by sending a boy through the manhole into the boiler, the water spaces and barrel can be thoroughly cleaned, and the tubes, which become coated with a hard scale, can be scraped, and renewed where damaged or burnt. At the same time all leaky stays round the fire-box should be drilled out and replaced by stays of S. C. iron.

The expense of these operations is fully compensated for by the increased efficiency and durability of the boiler.

The joints about a portable engine boiler next demand attention. These are a constant source of trouble and expense. In cases where the exhaust pipe passes through the boiler, the flange joints in connection with the cylinder eduction ports in the top plate of steam chest are continually failing, and the steam entering the leak causes a continual blast through the exhaust pipe, and a great loss of steam. In breaking and making these joints afresh, the screws which secure them, and which are tapped into the base of cylinders, break short off inside the boiler; the consequence is that the cylinders have to be lifted and the screws renewed, which is a very expensive and tedious job. A great improvement is to substitute studs for screws, with nuts inside the boiler. In some portables where the exhaust pipe passes along the top and outside the boiler, this leakage is avoided.

Failure often takes place in the joint or bedding of the cylinders on the boiler, the base or flange of the cylinders not being properly brought to a true bearing on the crown plate. This joint is well made with wire gauze, and red and white lead, but an equally good, if not better, joint is made with iron borings and Scotch cement.

Leakage is constantly taking place among the tubes, and among the bolts and studs connected with the boiler, viz.:—The fire-box bridge bolts, the cylinder and saddle bolts, and the studs securing the fire-bar bearers to the sides of box. Excessive leakage in the ends of the tubes is a sure sign of an accumulation of dirt behind the tube plate; this dirt being first removed, the tubes can be made tight by judicious caulking; continual caulking, however, is very injurious to the tubes and plate, and whenever this fails, the ferule should be withdrawn and replaced by one slightly larger in diameter. A good grummit for the heads of the fire-box bridge bolts is made of spun yarn, with a thin coating of Scotch cement; leakage in the saddle bolts is not easily remedied; being put in from the inside of boiler, great difficulty is experienced in reaching them. The fire-bar bearer studs are not made strong enough for the weight they have to carry, and when leaky are very troublesome; the best plan is to replace them by larger screws of S. C. iron.

It is almost unnecessary to add that the water-gauge cocks, the blow-out cock, and safety-valve fittings, require constant looking to, and should be always kept free from corrosion and in good working order.

It cannot be too often impressed upon engineers in charge of steam-boilers, that the great desiderata for their safe and economical working are :—careful engine-men, good and constant supply of pure water, entire freedom from dirt and corrosion, and tightness in every part; by a proper and systematic attention to these points a boiler can always be kept efficient and safe from accident, and will last for years.

Painting Zinc. — A difficulty is often experienced in causing oil colors to adhere to sheet zinc. Boettger recommends the employment of a mordant, so to speak, of the following composition :—One part of chloride of copper, 1 of nitrate of copper, and 1 of sal-ammoniac, are to be dissolved in 64 parts of water, to which solution is to be added 1 part of commercial hydrochloric acid. The sheets of zinc are to be brushed over with this liquid, which gives them a deep black color; in the course of from 12 to 24 hours they become dry, and to their now dirty gray surface a coat of any oil color will firmly adhere. Some sheets of zinc prepared in this way, and afterwards painted, have been found to entirely withstand all the atmospheric changes of winter and summer.

Cement for Steam and Gas Pipes.—The following directions are given for making cement impermeable by air and steam, which is said to be superior to any in use for steam and gas pipes :—Six parts of finely-powdered graphite, 3 parts of slaked lime, and 8 parts of sulphate, are mixed with 7 parts of boiled oil. The mass must be well kneaded until the mixture is perfect.

NEW THEORY OF PUDDLING.

THE AGENCY OF CARBONIC ACID GAS.

Mr. John F. Bennett, of Pittsburgh, who has taken a patent for the use of carbonic acid gas in the Bessemer converter —a process about to be tested in Sheffield, we understand—writes at length to the "Iron Age" (Dec. 3) on a kindred subject. After quoting Dr. Percy's theory of puddling, which has been the received theory of all writers from Kane in 1835 to Fairbairn in 1865, he objects to it in detail, and states his own views with at least considerable plausibility. The following are the points in the case :

The only air that enters the furnace passes up through the grate bars of the fireplace, and is wholly changed into carbonic acid gas. As there is not enough air to consume all the combustible matter, part of it passes off as distilled gases, and part of the carbonic acid gas is decomposed into carbonic oxide gas; in both cases not giving out their value, and so causing waste of fuel and loss of heat and time. The writer built a puddling furnace which is now in successful operation, into which is drawn, immediately beyond the fire bridge, a quantity of hot air equal to one-third of what passes through the grate bars. This scarcely suffices to burn all the combustible matters. In the Silesian gas puddling furnaces the supply of air is exactly proportioned to the combustible gases. So also in the Siemens' furnace. But if free oxygen did pass over with the unconsumed combustible gases, and would combine with carbonic acid sooner than with iron, how much rather would it prefer the gaseous carboniferous matters amongst which it is infused, to the partially liquid iron on the bed of the furnace, against the surface only of which it could impinge. Therefore, there is, practically, no free oxygen influencing the action in the puddling furnace.

With regard to the blue flames of carbonic oxide gas issuing from the surface of the molten metal, produced by the reaction between the carbon of the pig-iron and the oxygen of the oxidized compounds of pig-iron, as Dr. Percy states—these blue flames of carbonic oxide gas must have some other origin, inasmuch as the protoxide of iron in the puddling furnace cinder is increased at each operation, and not decreased, as would be the case if Dr. Percy were correct; also it is unknown in chemical reactions that the oxygen of the protoxide of iron can be removed by carbon. Nor will oxygen combine with carbon to form carbonic oxide gas so that it can be exhibited, for although carbon does undoubtedly unite with its equivalent oxygen to form carbonic oxide gas in the first instance, when they come together at the proper temperature, yet such is the affinity of carbonic oxide gas for oxygen, that at the moment of its formation, it combines with it and forms carbonic acid gas—or, in other words, if 1 atom of oxygen was present with 1 or more atoms of carbon at the proper temperature, carbonic acid gas would be produced and might be exhibited, but if 2 atoms of oxygen and 1 or more atoms of carbon were present, carbonic acid gas alone would be produced and exhibited; therefore, practically, oxygen burning with carbon would produce only carbonic acid gas, and not the well-known blue flames of carbonic oxide gas as exhibited in the puddling furnace of the iron works, or the black ash furnace of the alkali works. Therefore, says the author, the process of eliminating carbon from iron in the puddling furnace is not assisted by the oxygen of any part of the cinder, or of the oxidized compounds of iron added during the process.

Mr. Bennett's theory is as follows: On the bed of the puddling furnace we have molten pig-iron, consisting of iron, carbon, sulphur, phosphorus, silicon, manganese, aluminum, calcium, magnesium, etc., played over, surrounded, and permeated with hot carbonic acid gas. That portion of the atmosphere of carbonic acid gas that permeates the liquid pig-iron may be looked upon as liquid, thus allowing free play for chemical affinities to display themselves as readily as they do when different salts of hydrogen are dissolved in water and commixed. In the order of their affinity, the silicon and carbonic acid first combine, depositing carbon in the molten pig-iron, while the silicic acid is evolved as a gas in part and deposited in the liquid cinder in part. Co2x=Cx2 Si. O. While this operation is going on there is an increase of carbon in the molten pig-iron as shown by the experiments of Calvert and Johnson and M. Lan.

The carbonic acid next combines with the carbon forming carbonic oxide, which is evolved as a gas. Co 2 xC=2 Co. The carbonic acid next combines with the sulphur, depositing carbon and evolving sulphurous acid and sulphuric acid, which is in most part retained in the liquid cinder as sulphate. The carbonic acid next combines with the phosphorus, depositing carbon and evolving phosphorus and phosphoric acid, which is in most part retained in the liquid cinder as phosphate. The carbonic acid next combines with the manganese, depositing carbon and evolving manganous acid, which is in most part retained in the liquid cinder as protoxide. The minor impurities of magnesium, calcium, aluminum, etc., are removed in the same manner.

That this is substantially the order in which these impurities are removed may be shown in the action of the blast furnace, where, when these are the impurities of the iron ore smelted, if the manganese is deposited in the slag, so are the sulphur and phosphorus, while if the manganese remains in the pig-iron, so do also the sulphur and phosphorus. While these three last operations are going on, the carbon deposited is also acted upon by the carbonic acid and evolved as carbonic oxide gas.

While all these operations are going on, the iron is also acted upon by the carbonic acid, carbon deposited, and ferrous acid in part evolved as a gas and in part deposited in the liquid cinder as protoxide. While the action is taking place between the carbonic acid and the following substances, viz., silicon, carbon, sulphur, and phosphorus, both being hot, say 3,000° Fahrenheit, there is no diminution of temperature. When the action begins to take place between the carbonic acid and the iron, there is a deficiency of temperature manifest, and the iron begins to be pasty and capable of being agglutinated together, and so collected into balls, this deficiency of temperature being caused by the temperature of the carbonic acid being only 3,000° Fahrenheit, whereas pure iron requires a temperature of 5,000° Fahrenheit to become liquid, and in the action of the transfer of oxygen from one metal to another there is no heat made apparent; or, in other words, the heat lost by the taking away of the oxygen of the carbonic acid is at the same time restored by its combination with the iron.

NEW EXPLOSIVE AGENTS.

Compiled from the "Pall Mall Gazette."

NITRO-GLYCERINE.—Mr. Alfred Nobel, a Swedish engineer and chemist, was the first to attempt the application of nitro-glycerine as an explosive agent, although it had been known as a chemical curiosity since 1847. His original plan was to impregnate gunpowder with the liquid, thus adding very considerably to the destructive powers of the former. It is a peculiarity of nitro-glycerine that, although it explodes violently when submitted to a sudden and sharp concussion, it is flamed with difficulty by the simple application of heat or fire, and then burns very much like any inflammable, non-explosive liquid. About five years ago Mr. Nobel adopted the ingenious device of accomplishing the main explosion by a small preliminary detonation, by means of the ordinary mining fuze, with a small case containing gunpowder, or a metal cap containing detonating powder, attached to its extremity. Thus the destructive force of nitro-glycerine may be developed with tolerable certainty, no matter whether the liquid is more or less strongly confined.

The possibility of applying nitro-glycerine in its pure state as an efficient explosive agent, in mining and similar operations, having been thus demonstrated, Mr. Nobel proceeded to perfect the manufacture of the material, and to give illustrations in public of its extraordinary destructive powers, which have been estimated at 10 times as great as gunpowder.

The new "blasting oil" was first used in Sweden and Norway, where manufactories were established by Nobel, and subsequently in other countries; notwithstanding the difficulties and dangers to be encountered in the employment of a liquid of uncertain stability, possessed of poisonous properties, horribly dangerous to handle, and having the tendency to solidify at a temperature above the freezing point, when the danger attending its manipulation becomes greately increased. A succession of the most fearful disasters have occurred during the transport, manufacture, and manipulation of the substance, the first at Colon, and others in New York, California, Australia, and other parts of the world, also two destructive explosions last summer in Belgium and in Sweden (at Nobel's factory). The employment of nitro-glycerine has since been prohibited in the two last-named kingdoms, and the very name of the substance is now everywhere most properly regarded with a feeling of dread, which any modification in the properties of this destructive liquid will fail readily to dispel.

DYNAMITE.—These facts have led Mr. Nobel to contrive a safer modification of the liquid; the result has been the production of "dynamite," a buff-colored powder, somewhat oily or adhesive to the touch. This material is a somewhat crude nitro-glycerine preparation, and consists simply of a silicious earth (or any other inert powder), impregnated with a considerable quantity of nitro-glycerine. A solid, inert substance is thus made the vehicle for the application of the explosive liquid, and the disadvantages which specially attach to the fluid character of nitro-glycerine are set aside. But although nitro-glycerine in this form is safer to transport, and is applicable with more ease and certainty as a blasting agent than the liquid, its injurious influence upon the health of those employing it, and the possibility of its undergoing changes which may result in spontaneous explosion, are not overcome. Moreover, the physical character of dynamite renders it less convenient to handle than gunpowder and other solid explosives; and it is obviously less powerful than the undiluted liquid. Like nitro-glycerine in the pure state, dynamite will not explode upon simple application of a red-hot iron or flame, but if exposed to the effects of a detonation in immediate proximity to it, the violently destructive results obtained with the liquid are developed in proportion by the solid.

NYTRO-GLYCERINE AND GUN-COTTON.—Another preparation of this substance has lately been produced by Mr. Abel, Chemist to the War Department, and made the subject of some interesting experiments at Chatham and Woolwich. It is produced either in the form of hard granules, or of discs or pellets of compressed gun-cotton, containing about three-fourths their weight of nitro-glycerine. The nitro-glycerine is thus held absorbed within a porous, solid substance, which is itself endowed with strong explosive properties. All contact of the nitro-glycerine with the air, and with those handling this preparation, is prevented by a hard impervious coating with which the grains or discs are provided. This material would therefore appear to be decidedly safer and more convenient to handle, transport, and preserve, besides being more powerful as an explosive than dynamite. If lighted in open air it simply burns, without any explosive effect; but when confined it does not, like dynamite or the liquid nitro-glycerine, require a detonating fuse for the development of its explosive power, though its violent explosion, even in open air, may be brought about in that way, just as in the case of the other substances.

Improved Gun-Cotton.—Unfortunately for the interests of nitro-glycerine, a new and valuable addition to our knowledge of gun-cotton, recently made at Woolwich, renders it very doubtful whether the explosive liquid, in whatever form it may be presented, is likely to enter into successful competition with that material. It has been found that the explosive force of gun-cotton may, like that of nitro-glycerine, be developed by the exposure of the substance to the sudden concussion produced by a detonation; and that if exploded by that agency, the suddenness and consequent violence of its action greatly exceed that of its explosion by means of a highly heated body of flame. This is a most important discovery, and one which invests gun-cotton with totally new and valuable characteristics.

Some remarkable results have been already obtained with this new mode of exploding gun-cotton. Large blocks of granite and iron plates of some thickness have been shattered by exploding small charges of gun-cotton, which simply rested upon their upper surfaces. Long charges or trains of gun-cotton, simply placed upon the ground against stockades of great strength, and wholly unconfined, have been exploded by means of detonating fuses placed at the centre or at one end of the train, and produced uniformly destructive effects throughout their entire length, the results corresponding to those produced by eight or ten times the amount of gunpowder when applied under the most favorable conditions. Mining and quarrying operations with gun-cotton applied in the new manner, have furnished results quite equal to those obtained with nitro-glycerine, and have proved conclusively that if gun-cotton is exploded by detonation it is unnecessary to confine the charge in the blast-hole by the process of hard-tamping, as the explosion of the entire charge takes place too suddenly for its effects to be appreciably diminished by the line of escape presented by the blast-hole. Thus, the most dangerous of all operations connected with mining may be dispensed with when gun-cotton fired by the new system is employed.

It will readily be observed that this discovery, which we believe is due to Messrs. Abel and Brown, of the War Office Chemical Establishment, is likely to be attended with most important results. It has been said, and said justly, that if you want gun-cotton to exert itself you must coax it into the belief that it has a great deal to do. You must give it bonds to break and physical obstacles to overcome, with no outlet or possibility of escape. But now, gun-cotton will exert itself, and put forth more than what was believed to be its full strength, whether it sees any work to do or not. This discovery, therefore, can hardly fail to lead to the universal adoption of gun-cotton for mining purposes, as soon as its new properties become generally known.

In connection with possible military applications the discovery is invaluable. There can no longer be any doubt what agent should be employed for the breaching of stockades and the like; and the absence of all necessity for the use of strong confining envelopes will have an important bearing upon the employment of gun-cotton for torpedoes and all submarine explosive operations, besides greatly simplifying mining and breaching operations in the field. We have, in fact, discovered several new advantages to add to those which already had sufficed to recommend gun-cotton as an explosive agent in preference to all others.

Isaac Newton, Esq., late Chief Engineer in the Navy, Engineer of the Monitor during her first engagement, and an accomplished scholar in all that pertains to ships, steam, and naval affairs, is associated with Gen. McClellan in the completion of the Stevens battery.

WASTE OF WOOD.

STATISTICS—THE REMEDY—IRON AND CONCRETE STRUCTURES.

From the last report of the United States Department of Agriculture it appears that unless measures are taken immediately to replace by new plantations the supplies withdrawn by the destruction of our old forests, there will be an actual famine for wood in this country within the next 30 years. It is estimated that from 1850 to 1860 no less than 50,000,000 acres of new land were brought under cultivation, of which two-fifths were timber land. And in the decade ending 1870 there will be no less than 100,000,000 acres so reclaimed. In the single State of New York, from 1850 to 1860, there were reclaimed from the forest and brought into cultivation no less than 1,967,433 acres of land. All these acres will never again be devoted to timber growing, and still the destruction goes on.

The great consumption of wood is for building, fuel, and railway sleepers. The value of the farms of the United States in 1860 was $6,654,045,700, while the value of the lumber improvements was $3,322,522,000. All this has been cut from the soil, and most of it within 30 years. Little or nothing has been done to replace it. The sleepers used on the railroads of our country from 1850 to 1860 cost $23,063,957. More than 100,000,000 railway sleepers are now in use, and as these are almost entirely hard wood, and last but 2 to 5 years, it will be seen that the annual supply for this purpose is enormous, and increasing as fast as new railroads are built. In a single year there was used for repairs of railroads and railroad buildings and cars in the United States, no less than $38,000,000 worth of wood.

There are no less than 477,623 artisans in wood in this country. If we estimate the value of their production at the low price of $1,000 each per annum, we have the still greater aggregate of an industry of $500,000,000 per annum dependent solely on wood. It is a noteworthy fact that wood in all its branches of manufacture and use, pays more than one-half the entire internal revenue of the United States, and no less than 66 trades depend upon wood as bare material for their labor. The wood fuel used for locomotives in the United States reached the enormous figure of $56,000,000 in a single year.

Besides the scarcity and increased cost of wood for all these purposes, a more serious loss is likely to result to agriculture, from the greater severity of the climate, due to the loss of the forests. The irregularity and extremes of temperature we now endure, were not formerly known.

These are startling facts, and their importance cannot be too quickly or too seriously considered by governments, communities, engineers, farmers—all men. The people should rise in self-defence, as in case of foreign invasion. Without discussing at this time the proper work of Government in the matter, nor of farmers in replanting and sparing forests for their individual protection, we would urge engineers, builders, and all consumers of wood in great and permanent structures, to renew their efforts to cheapen the other and more plentiful materials of nature, and more especially to *avoid the use of perishable wood.* In the majority of cases the use of wood costs more in the long run than stone, brick, cement, iron. Decay outruns interest.

Wooden railway bridges do not pay anywhere, and wooden sleepers are not found to pay in many countries where this material is peculiarly scarce and perishable. Iron sleepers, with a small amount of wood in pockets, to give the necessary elasticity, are really permanent and safe, and would be economical to-day on lines of heavy traffic in our Eastern States. The wear and tear of rails and rolling stock directly due to the decay and the cutting and mashing of wooden sleepers, the cost of their renewal every five years, and the better support and increased bearing of the rail obtainable with iron, are all sound and weighty arguments in its favor. Because simple stone blocks were found too rigid, the idea of stone permanent way seems to be entirely discarded. But where stone is plentiful and easily wrought, the placing of wooden pockets in large blocks of it would cost little more than wooden sleepers, and be sufficiently elastic.

Excepting only wooden shipbuilding, the most unreasonable and not the least extensive use of wood is in the floors of great stone and brick city houses. Probably three-quarters of the very first class and most costly buildings erecting in our cities, have wooden floors. The first cost of iron is certainly a great temptation to avoid it; but higher rates of insurance and inevitable destruction by fire at some time, will eat up the saving. If wood and iron were of equal price, the permanence of the latter should warrant its adoption in all the better class of buildings. There is some reason and hope in legislation on this subject. When a man's wooden-floored warehouse is gutted by fire, the verdict is, "served him right." But when this conflagration lights the warehouses of his neighbors, they have a rightful and should have a legal claim against him. For farm buildings and country houses brick should be more generally adopted as an economical measure; the repeated painting and inevitable decay and reconstruction of wood cost more in the end Concrete is getting into larger use, especially abroad; it is cheap and permanent. This subject will be more fully referred to in another article.

What engineers and builders have to do is to *cheapen* brick, concrete, artificial stone, iron, and the modes of moulding them into houses and structures. The wood question is so positively alarming, that a great demand—a rush—is likely to be made in the new direction, and every improvement will be gladly and widely welcomed. We know of no business likely to be more remunerative than the production of a cheap mineral building material, on a large scale.

As to wood fuel, the grand consumption of locomotives and steamers is already much abridged. The charcoal furnace is a great destroyer of forests, and we look to the improvement in coal furnaces—high and large stacks, better hot blast, better fluxing, and the purification of ores and of irons in subsequent treatment—to lessen the necessity and the demand for charcoal-iron.

It is singularly fortunate that the material we want so much to preserve, is the material we ought so little to use. Wood in heavy and exposed structures, and especially when subjected to wear, is utterly perishable. It immediately begins to depreciate in strength and value, and its short life is but a series of paintings, patchings, splicings, and repairs. For this reason it is after a short service not only unreliable, but so yielding as to decrease the service and durability of surrounding parts. If this is not enough, the injury to agriculture by the destruction of forests, should be enough to warrant every public and private effort to preserve them. The cultivated taste of the times has found nothing more suitable for furniture and decoration than the natural woods, and whatever of this material can be spared from the hill sides can be advantageously employed for these and similar purposes.

In the West this subject is better understood than among us, and laws have already been passed in Iowa, Kansas, Missouri, and other States, looking to the growth of forests, such as the exemption of made and natural wood growths from taxes. And the timber nurseries of the West are already vast in extent. In some parts the first thing the farmer does is to plant the fast-growing cotton wood, and the next is to plant better wood to take its place. In the East, where timber has been more plentiful, and is soon to be more scarce than in the West even, and where more durable building materials are more cheaply produced and more needed, the subject has not received proper attention.

How to Lay out a City.—The "New York Times" argues that the right-angular plan has turned out as inconvenient as the cow-path system, and advocates for situations like New York, a main longitudinal avenue of great width, with rectangular and diagonal streets leading from it. There should certainly be some other means of getting from corner to corner of a series of square blocks, than going round the town or "playing a game of checkers" through its centre. Diagonal streets may yet have to be cut through our right-angled cities. Baron Haussman has spent 375 millions in altering the map of Paris, during the last fifteen years.

Power Looms were first constructed in England by Cartwright in 1787, and first started in this country on the improved plans of Moody, an American, by Lowell (after whom the city of looms was named) in 1815.

COMPRESSED SLACK COAL.

Mr. Warington W. Smyth's report on the art of mining and metallurgy at the Paris Exhibition.

Within the last few years, careful experiments, conducted by the administration, have proved, what was long doubted, that France possesses coals excellently adapted for sea service; and for some time past no other than French coal has been used in the Imperial navy. But for these purposes the fossil fuels from different localities have to be judiciously selected and mingled in certain proportions. Taking the coal as a whole, it is noticeable that it makes much more small and dust than our own, and is more frequently apt to be "dirty" or mixed with shale and clay. It hence results, that the French coalmasters have been driven to pay a special attention to methods of cleaning their produce and utilizing the "slack," *menu*, or small coal. At the great Exhibition in 1851, Bérard's coal-washing machine came before us as a novelty, although it was only in certain details that it could rightly be so considered; and, besides several contrivances for that purpose introduced more recently, a great variety of ingenious apparatus has been brought into use for making "patent fuel," *agglomeres*—that is, for pressing the small coal into cakes of various forms by the aid of a small amount of some binding material. These *briquettes* are highly reported upon for naval use; in their carriage to the ports there is a loss of only 1 per cent., against from 6 to 10 per cent. on lump coal; and when stored abroad they are found after two years' exposure scarcely at all injured, whilst ordinary coal would have suffered to the extent of 50 per cent. Moreover, they are free from ash, and may be made of a mixture of flaming and of dry coal, or of those varieties which have a more free-burning and a more calorific property respectively, in such a ratio as to give the best effect in getting up and maintaining steam. The late Exposition abounded with examples of the machinery and the products of this manufacture; and, although we are not in Great Britain without a similar industry, attention may fairly be called to the subject in the interest of the millions of tons of small coal and of inferior qualities which we are every year actually getting rid of as refuse.

As early as 1833, Messrs. Marsais and Ferrand took out a patent for this purpose, but it was not until 1843 that the agglomerated coal began to be produced in any quantity, and some more years elapsed before the machinery was so far improved by several different engineers as to lead to the present large scale of the manufacture. The St. Etienne Company, by introducing an enormous hydraulic pressure, need only to add $5\frac{1}{2}$ per cent. of pitch (*brai sec*) to solidify the mass. The stack of rectangular blocks left outside the St. Etienne shed in the "park," throughout the heavy rains in April, gave good testimony to the thorough compactness and durability which had been thus attained.

The greater part of the French makers appear to have adopted the circular arrangement of the Messrs. Revollier, and of Mr. Evrard and M. Dehaynin.

In this machine the cylinders are disposed as the radii of a circle, in which the slack, after being heated by a current of steam, and mingled by very ingenious apparatus with the pitch, is pressed by pistons and formed either into cylindrical or hexagonal blocks of convenient length. The rate of production appears to be in practice, 10 tons per hour with one machine, requiring an engine of 50-horse power to work it, and the extreme limit of pressure being 100 atmospheres.

The prices of the St. Etienne compressed fuel are high; the first quality, which contains only 2.10 per cent. of ash, is marked at 28 francs per ton; the second, with 5 per cent., at 26 francs; whilst the best block coal rules at from 19 francs to $23\frac{1}{2}$ francs, and the small at $9\frac{1}{2}$ francs to $15\frac{1}{2}$ francs. The very small proportion of gas, tar, or pitchy matter introduced into the mass at this work, can scarcely be considered as a general guide, since different qualities of coal will need some more and some less of binding material.

M. Felix Dehaynin, a producer of no less than 175,000 tons of *agglomeres* in the year, exhibited drawings of the Evrard machine as modified by himself, and employed at his three works, in which 500 people are engaged. The company called the "Ocean," at Paris, were also exhibitors of drawings and of the apparatus for the same purpose, known by the name of its inventor, M. Mazeline.

As an adjunct in these operations, an ingenious machine by Hanrez & Co. may be noticed. It is constructed for the dying of small washed coal by the revolution of a screw within a revolving perforated cylinder, and is stated to dry five tons per hour.

We could wish that coalworkers, mineral landowners, and capitalists, would note these various indications of what is now becoming in France an important trade. Without being unmindful that several companies have been established in South Wales and elsewhere for a similar manufacture, we cannot but be conscious that their action is but an infinitesimal set-off against the wholesale waste of slack that takes place in this country. It is not only that the small coal cut and broken from the salable part of seams is, in most of our districts, thrown into goaf and gob by the tens of thousands of tons, but those proportions of beds, often some feet in thickness, which are intermixed with stone or sulphur, or which make a larger than usual proportion of slack, are at once rejected as useless, and acres of such coal are abandoned to be inextricably mixed up with broken roof and heaving floor, although of no worse quality than would be turned to advantage in many a French colliery. It is impossible, in the hard competition of the times, to blame individuals for this sin against the economical use of Nature's gifts; but it is a discredit to the country at large, and will, among our descendants, entail many an anathema on the selfish stupidity of their forefathers. American miners take notice.

Electro-Plating iron with copper and brass is successfully carried on in France, in the following simple manner:—The iron object is coated with a varnish of resin, dissolved in benzine. This is then coated with plumbago, and the copper deposited as usual. By this means the peeling off of the thin layer of copper is obviated.

Saw Works.—Disston's in Philadelphia comprise 7 buildings, having an area of 500,000 square feet, and employ 400 hands.

THE INSTITUTION OF CIVIL ENGINEERS.

HISTORY OF THE SOCIETY—ITS NEW HOUSE IN LONDON.

Compiled from "Engineering."

Former Societies.—Although the Society of Arts was founded in 1754, the English engineers had no representative body, no arranged and adequate means for the communication of ideas, till much later. In 1768 Smeaton and a few friends formed a more or less convivial engineering club which met at the Queen's Head Tavern in Holborn, and lasted some 20 years, but left no professional records. In 1792 Smeaton was about to reorganize the society in a "better and more respectable form," but his death prevented. His friends, however, did reorganize it, and commenced a series of fortnightly meetings on April 15, 1793, at the Crown and Anchor in the Strand; there was better order, but not less eating and drinking. The "Smeatonian Society of Civil Engineers" still exists, and holds monthly meetings at the Freemason's Tavern during Parliamentary sessions, but its pith and sap have been absorbed by its single vigorous branch, the "Institution of Civil Engineers."

History of the Institution.—In 1817 William Maudslay, Henry B. Palmer, Joshua Field, James Jones, Joshua Collinge, and James Ashwell, formed a society and drew up rules which are still maintained with some modification. In 1821, Thomas Telford, appreciating the value of such a society, and foreseeing how it might extend in professional influence and power if well managed, accepted the presidency. In his inaugural he said that the institution had arisen from the wants of society, and being the result of its present state promises to be both useful and lasting. Under the able guidance and powerful influence of Telford the society grew and prospered. Its meetings were held at No. 1 Cannon Row, Westminster, till 1839, when it erected its present offices, No. 25 Great George Street. On the 3d of June, 1828, it obtained a royal charter, and was incorporated under the title of the "Institution of Civil Engineers." Telford's devotion to the interests of his protégé increased, as he gave up professional pursuits in his later years, and he remained president till his death in 1834. The second president, Walker, retained the chair for 10 years, and Sir John Rennie remained in office 3 years. The term of presidentship is now 2 years, and since Rennie, 11 members have filled the chair. At the present time the institution has 1,689 members, of whom 16 are "honorary," 641 "members," 909 "associates," and 123 "students."

New Building—Cost.—The insufficient accommodation of the old house led to inquiry as to the best site and plans for a larger building. An eligible site and structure in Victoria Street would have cost £26,000 to meet which the institution had the rent of the old house, £4,000, and £18,000 available property; this would have entailed a debt of £4,000. The old site, 25 Great George Street, sufficiently increased by the purchase of adjoining property, was therefore obtained at a yearly rental for 99 years of £659, with the privilege of purchase within 10 years for £12,000. The cost of the alterations and extensions of the building was £11,650. The architect is Mr. J. H. Wyatt; the contractors Messrs. Holland & Hannem.

Main Features — Rooms. — The main feature of the new design was the construction of an ample meeting room in place of the old cramped and awkward theatre 44 feet 9 inches by 24 feet 8 inches; the improvement of the library, and some means to avoid the undue crush of the annual conversazione. At the same time, the old façade and entrance were to remain. The original plans (see "Engineering," vol. V.) were reconsidered, and the present building is as follows:

On the left of the main hall is the secretary's room 24 by 17 feet, and a clerk's office 17 feet 7 inches by 15 feet. The two are separated by a glazed partition which can be removed upon occasion. At the end of the main hall, which is paved with tesselated marble, an archway under the main staircase, decorated with bronze gas standards and statuary, leads to the lobby leading to the council room, 21 feet 6 inches by 31 feet 10 inches, on the left, and the members reading and writing room, 40 feet by 28 feet 4 inches, on the right, and to the lavatories. On Tuesday evenings tea and coffee are served on a removable counter in the reading room, and on conversazione nights the partition between the reading and the council rooms will be removed, making a spacious refreshment room. At the back of the council room stairs lead to the kitchen below, and other stairs to the rear of the president's chair in the theatre above. In the basement, approached by a separate staircase, is the strong room, $12\frac{1}{2}$ feet by 7 feet.

The Theatre.—The main staircase, 4 feet wide, occupies a rectangular well 18 feet 6 inches by 21 feet, extending unbroken to the lantern above, 48 feet from the ground level. A rise of about 14 feet brings up to the level of the meeting-room or theatre on which the principal care of the architect has been expended. It has a clear area of 60 feet by 40 feet, with a height of 30 feet from the floor to the springing of the dome by which the room is lighted. There are four entrances, the doorways of which are handsomely executed in oak. The principal entrance opens from a 6-foot landing at the head of the main stairs, which also extends to the library. A second access is obtained on the extreme left, by a gallery, and is intended for the entry of members who arrive after the proceedings have commenced. On the right two more doors open from another gallery.

The arrangement of the seats in the theatre has been carefully devised. The President's chair occupies a point opposite the space between the central doorways, and from this, as a centre, a series of semicircular platforms have been laid, each tier from the council table to the opposite wall rising above the other, so that the outer row is about 3 feet from the ground. The objectionable plan of having a clear avenue down the centre of the room to the President's chair, a plan which invariably interrupts the attention of the meeting by the entry of late members, has been avoided. The circular benches, arranged upon the platform tiers, are placed 2 feet 7 inches apart from back to back, so that ample sitting accommodation is provided for 375 people, which the room is calculated to hold without a gallery. There is a small room at the back of the theatre, devoted to the use of diagrams, etc.

The sides of the meeting-room are treated with Doric and Ionic pilasters, terminating in sufficiently enriched cantilevers and cornices at the ceiling. The bays left between the pilasters will ultimately be filled with the pictures belonging to the Institution. At present, however, the only decorations will consist of brackets carrying the busts which adorned the old building. The principal of these is the marble bust of Telford, which will fill a conspicuous place in the library. Of the others, the main ones will be the portraits of Dr. Olinthus Gregory, Thomas Tregold, Professor Faraday, Sir Robert Peel, John Smeaton, Watt, Rennie, the Stephensons (father and son), Maudslay, the elder and younger Brunel, Locke, John Fowler, Hawkshaw, Joshua Field, Bryan Donkin, G. P. Bidder, and Rendel.

Lighting.—Eight lunettes—4 on the north and 4 on the south side of the meeting hall—aid the light thrown by a large central dome 19 feet in diameter, enclosed in an outer dome, so that the light is passed through a double medium. By night the theatre is illuminated by 3 sunlights; the central one in the middle of the dome has 63 lights, and the 2 side ones 28 lights each. Two grated openings are provided in the ceiling for ventilation.

Heating.—Thirteen grated openings placed around the room about 15 inches above the floor, and openings in the risers under the seats, admit the warmed air forced from the basement at the rate of 400,000 cubic feet per hour, being an allowance of 800 cubic feet per hour for 500 people. Fresh air is taken from without and carried along an underground channel leading into the basement. At the extremity of this channel a fan, driven by a 1-horse gas engine, forces the air into a chamber, where it is warmed in winter, and can be cooled in summer. The apparatus employed for warming the air consists of a series of hot water pipes, 4 inches in diameter, disposed in horizontal tiers, and so arranged that the entire volume of air used for ventilation must be passed amongst the spaces between them before it leaves the chamber. The axis of the fan used for forcing the air into the building is situated parallel with that of the air channels, and it carries two blades placed at 50°, the diameter being 3 feet. Means have also been provided for filtering the air before admitting it, and in summer a cold water spray will be forced against a fine wire gauze screen covering the mouth of the channel to cool the air on its passage. Valves are placed in the different branches to regulate the admission, and an independent coil is placed in the hall to warm the entry to the building.

Library.—In the library, 42 feet by 28 feet, the first and second floors of the old building have been thrown into one, and a gallery supported on brackets, is carried around the room at the old upper floor level; this gallery is wide enough to contain bookcases and leave space enough for stools and desks for readers. The library is illuminated with two 28-burner sunlights, and sufficient ventilation is secured by gratings in the ceiling. The top floor has been made into one spacious loft with an excellent light for the preparation and storage of diagrams.

Such is the house the Institution of Civil Engineers has built and garnished for itself in the fiftieth year of its life.

The Park Bank.—This showy, and in many respects splendid structure, occupying part of the site of the old museum opposite the Astor House, was opened in December. The façade is of white marble, richly decorated in the classic style. The striking features are the double rows of columns supporting the portico, the collossal statuary, and the lofty Mansard roof. The central hall, 12 ft. wide by 50 ft. long, leads to the banking-room, 56 by 90 ft., and 40 ft. high at the springing of the glass and iron dome. The decoration of the walls is Pompeian, and the effect of the warm tints is pronounced very fine. At the 4 corners are 4 medallions representing Art, Science, Industry, and Justice. The wainscoting is 5½ ft. deep, with stiles of dove-colored marble, and panels of reddish Tennessee marble. The screen is of bronze, with black marble shelves and plate glass windows. The desks and counters are of mahogany. The safes cover a space 20 by 7 ft., and are 13 ft. high. The room is warmed by a steam pipe running along the bases of the internal divisions, and a number of Gold's heaters. On 3 sides of the room are galleries 8 and 10 ft. in width; from 1 of them opens the book-room, 50 by 9 ft.; from another, the directors' room, 24 by 17 ft., decorated like the banking-room, and richly furnished. On the right of the main hall is the bank parlor, 48 by 20 ft., and 17 feet high. It is velvet carpeted, walnut-root wainscoted, Marcott decorated and furnished, and altogether princely. The space on the other side of the hall, and in the 2d story of the front building, is divided into spacious rooms for other banking and insurance companies.

The safety deposit vault in the basement of the building is built of granite blocks 2 feet thick, and contains 486 safes. The foundations of it form a mass of masonry 49 by 24 feet in plan, and 24 feet high. The front foundation wall of the building is 32 feet deep below the sidewalk, and from 8 to 11 feet thick. A 3-horse power caloric engine in the basement forces water 95 feet high to a 3,000 gal. tank. The building is essentially fire-proof. The floors are iron girders and brick arches.

The building cost $700,000 ; the lot $350,000. The architect is Mr. G. H. Thomas ; the builder, Mr. G. T. Smith ; the carpenters, Messrs. Smith & True. The statuary is by Mr. R. E. Launitz.

LOCOMOTIVES FOR HEAVY GRADES.

The system of locomotives for the Mont Cenis Railway is thus commented upon in "Engineering." The construction of a railway over Mont Cenis, to be worked until the completion of the great tunnel, was a work creditable in every way to English enterprise and engineering skill. But we cannot the less disapprove of the absurdly complicated system of locomotive power employed to work in it.

The gradients on this line are 1 in 12, and the gauge 3 feet 7 inches. Messrs. Fell and Alexander, engineers, have respectively reinvented and worked out the old Vignoles-Ericsson-Sellers system of mid rail and engines with gripping wheels —a scheme as needless as a fifth wheel to a coach. These engines have frequently broken down, and it has been sought to throw the discredit upon the French makers, MM. Gouin who are among the very first makers in France, whose work —and they have made nearly 1,000 locomotives—gives no trouble on other lines.

It is now understood that a totally new class of engines will be made for the Mont Cenis line by MM. Cail & Co., the eminent locomotive constructors of Paris and Lille. The horizontal wheels are to be co nected by spur gearing, and so driven by independent cylinders; whereas, in the present complicated plan, the 4 coupled driving wheels and the 4 gripping wheels are worked from a single pair of cylinders. The new engines, which have been designed by Mr. J. R. Crampton, will certainly be superior to those now on the line.

But our authority concludes the gripping wheels and mid rails unnecessary, for the following reasons : Inclines of 1 in $18\frac{3}{4}$ had been regularly worked for 6 years on the Virginia Central Railway, the engines drawing from twice to three times their own weight behind them. Inclines of 1 in 10 had been worked during the winter of 1852–53 on the Baltimore and Ohio Railway, the coupled engines, having the whole of their own weight available for adhesion, drawing a load equal to their own weight behind them. At the opening, too, of the Mont Cenis Railway, last summer, the engine went up with its train, drawing its assigned load by the adhesion due to its own weight, the "gripping wheels" not being put in action at all.

It is quite certain that the adhesion of the driving wheels on a clean rail is often from one-fourth to one-third, and in some well-attested cases even three-eighths of the weight, and it is abundantly capable of proof that an engine or steam carriage, with its whole weight and load available for adhesion, can ascend inclines of 1 in 12 in any and all weathers.

THE NITRATE STEEL.

The controversy regarding the Heaton process has overrun the columns of the engineering press, into the London "Times." The only conclusion we are able to draw from the great mass of matter published, is that Mr. Heaton's claim to have made soft, uniform, homogeneous rails and bars, without remelting the first product of the converter, conflicts with the chemical possibilities as we now understand them. Says "Engineering:" The highest chemical authority in the kingdom, Professor Miller, has analyzed the Heaton metal, from samples taken by himself direct from Mr. Heaton's converters and rolling mill, and has found, as was to have been expected, numerous and extensive impurities, which unmistakably indicate not only a variable, but a very inferior, if not worthless quality. One sample of "crude steel" had almost

3 per cent. of impurities, of which 1.8 per cent. were carbon. Another sample of this steel after it had been simply cut, piled, heated, and rolled, had nearly 2 per cent. of impurities with 1 per cent. of carbon. Any so-called steel made from highly phosphuretted pig, by a hasty boiling over nitrate of soda, including the incorporation into its own mass of a lump of cast-iron at the moment when the nitrate floats to the surface, could not possibly be expected to be uniform in quality, nor could it be expected to be of good quality in any case. A correspondent of the same paper says: The secondary or resultant product obtained by merely cutting, piling, beating, and hammering while in a spongy state, appears to have a wonderfully different chemical composition, one-half of the carbon being removed. This, it is tolerably certain, would not be the case with any other steel. A puddled steel, a crucible steel, or a Bessemer steel bar contains as much and no more carbon than the bloom, blister bar, or ingot from which it was made. But the secondary product of the Heaton process, although it is asserted to contain 1 per cent. of carbon, is nevertheless pronounced to be "malleable iron of the finest and purest quality." As to the authorship of the process, the authority first quoted says: Nor is Mr. Heaton even the inventor or discoverer of the use of nitrate of soda for purifying iron. He has invented merely a mode of using it, whereby it was kept or supposed to be kept at the bottom of the metal charge until the oxygen of the nitrate is given off. He first places the nitrate in the bottom of his converter, and to prevent it from at once floating to the top when the charge is poured upon it, he fastens it down by a cast-iron plate perforated with holes to allow the melted iron to obtain access to the nitrate, and to allow the oxygen thus evolved to rise.

This authority, however, does not attempt to *write down* the new process, but farther says: Mr. Heaton may be quite sure that his experiments in making steel from common brands of iron are watched with the greatest interest, and, so far as the iron trade is concerned, with all the hope that is possible in the face of so much conflicting evidence. If his assertions are true, he will, by another year, have added at least ten millions to the value of the iron now made in Great Britain, taking the value of his professed improvement at £2 10s. a ton only on 4,000,000 tons. His mode of treating melted pig-iron is much more expeditions than puddling, his plant is inexpensive, and the alleged increase of value of iron treated by his process is even greater than we have just estimated. A report to the Austrian government by Mr. Fred. Kohn takes an unfavorable view of the Heaton process, and in the matter of cost, states as follows: The difference between the price of phosphoric pig-iron and of pig-iron which is comparatively free from phosphorus, is about the same as the price of the nitrate of soda; it is therefore obviously simpler to purchase the dearer pig-iron, and to produce really pure steel from it, than to purify the inferior pig-iron in a certainly very incomplete manner, and to spend for the chemicals employed for this purification the whole balance derived from the difference in the prices of good and bad pig-iron.

The points in Mr. Bessemer's letter to the London "Times" are: 1st.—The inference to be drawn from a previous comparison of Heaton's and Bessemer's processes in the "Times" is that Mr. Heaton can by his process produce, from a cheap and inferior pig-iron, steel of a similar character to that obtained from a more expensive raw material by the Bessemer process. That is, however, far from being the case, for Bessemer steel is cast-steel—that is, steel made into a perfectly homogeneous mass while in a fluid state—and to that circumstance alone owes its great value as a material for the manufacture of railway bars, etc. 2d.—Whenever solid substances are converted into gas, a vast amount of heat is absorbed and rendered latent; hence in the Heaton process so much heat is abstracted from the metal in generating oxygen gas by the decomposition of nitrate of soda that the metal solidifies while in a state of mechanical admixture with the sand and soda, and thus, instead of obtaining fluid cast-steel by his process, Mr. Heaton obtains only a lump of spongy, porous metal, intermixed throughout with slags and scoria, and having the general characteristics and properties of ordinary puddled-iron or puddled-steel, but which is only obtained at a cost (for nitrate of soda) of more than double that of the ordinary puddling process. 3d.—The Heaton crude metal may, in common with puddled-iron of every description, be made into cast-steel by resorting to the old and costly Sheffield process of melting in crucibles, a process which consumes about $3\frac{1}{2}$ tons of coke for every ton of metal so melted, and with the additional cost of wages, crucibles, etc.; this melting process alone costs from £5 to £6 per ton. Hence, although Mr. Heaton starts with a cheap pig-iron, giving him an advantage of 20s. to 30s. per ton over the cost of the Bessemer raw material, he nevertheless employs for the conversion of 1 ton of pig-iron (according to Dr. Miller's report), no less than 270 pounds of nitrate of soda, which, at the present market price of 15s. per cwt., is equal to 36s. on the ton of crude iron, thus bringing up the cost of the materials employed in making 1 ton of crude steel by the Heaton process several shillings per ton above the cost of the high-class iron used in the Bessemer process; and we must add to the cost of the Heaton crude steel the additional cost of £5 to £6 per ton for melting.

In Mr. Heaton's reply the points are: 1st.—His plant is very cheap compared with Bessemer's. 2d.—The cooling effect Mr. Bessemer refers to is far outbalanced in his own process by the cooling effected in his converter by the prodigious volume of cold air forced through it for from 20 to 40 minutes. Which will carry off most heat, such a volume of air, or the oxygen evolved from 224 pounds of crude nitrate to the ton of steel? 3d.—Mr. Bessemer says his steel is a solid homogeneous mass, entirely free from scoria or other impurities, whereas mine is not, owing, he says, to the "mechanical admixture with the sand and soda." This is not the case. The slag, owing to its small specific gravity and to its extreme fluidity, rises to the surface of the molten metal, leaving the subjacent steel free from slag or scoria. It is not the fact that sand is necessarily employed; but were it so, the proportion of alkali is so great that the slag formed would be, and is, perfectly liquid, and is not mixed in any sensible quantity with the mass of steel in the converter, upon which it floats, as I have already observed. 4th.—As to the statement that "Heaton obtains only a lump of spongy porous metal, intermixed throughout with slag and scoria," he says: Steel from my converters passes at once either into my patent reverberatory furnace, or into a furnace of Mr. Siemens, and is kept in a molten state and thence run into ingots, as homogeneous and to the full as good as Mr. Bessemer's. Mr. Bessemer knows that his own steel has been proved by Mr. Siemens to be greatly improved by being thus kept for some time in fusion after it has been poured out of his converter as Bessemer crude steel. It is, therefore, not a fact that my "crude metal can be made into cast-steel only by resorting to the old and costly Sheffield process of melting in crucibles." 5th.—With reference to the nitrate employed: But the circumstances under which the experiments of Dr. Miller were carried on were purely exceptional, and the proportion of nitrate usually employed is not, as Mr. Bessemer states, 270 pounds, at a cost of 36s., but 224 pounds, at a cost of 28s. 6d., taking the extraordinary high prices of nitrate that at present prevail. Ten per cent. of nitrates is all that I have found necessary for the production of a ton of steel from inferior brands, and considerably less than 10 per cent. for superior brands. 6th.—As to quality, Mr. Heaton says: I have but just turned out 40 tons of steel rails direct from my converter, without any remelting, rails of a fine fracture, neither "fibrous" nor "laminated," but quite as homogeneous as Mr. Bessemer's, resisting the ordinary mechanical tests for steel rails, and produced at a cost with which no Bessemer steel can compete. Further, such orders are in course of execution.

To which Mr. Bessemer replies in another long letter to the "Times," substantially this: Heaton's apparatus is less perfectly developed, and therefore less costly, but 10 per cent. on the cost of the Bessemer apparatus does not amount to over 2s. per ton on the steel produced. As to the cooling action of the air, the heat actually produced in the Bessemer vessel is the most intense known in metallurgical operations. That the Heaton metal is not produced in a liquid state, and has therefore to be melted by another operation, in order to be as sound and valuable as Bessemer's, viz., *steel*, is officially stated by Dr. Miller in his report, and by Mr. Heaton. The former says, the product of the converter was poured on the floor in a pasty state, and then broken up and melted in pots. Mr. Heaton mentions, in his cost sheet, £5. 10s. per ton for remelting in crucibles. He also told Mr. Bessemer, as a reason why he should not be proceeded against as an infringer of the Bessemer patents, that he did not produce ingots of fluid steel by his (Heaton's)process. Mr. Bessemer admits that his own process could not make good steel from Cleveland iron, but states that the 65s. and 70s. pig that he does use, makes cheaper steel than the cheapest Cleveland pig + 28s. per ton for nitrates.

As to the invalidity of the Heaton patents for the use of nitrates, Mr. Bessemer replies at great length, citing some old patents;* and stating that he was himself the first to make steel by purely chemical means—by simply passing oxygen through the molten iron without the use of fuel, and that his patents claim the use for this purpose, of any oxygen-bearing substance. Mr. Bessemer says he has recently obtained patents for means of using the nitrates, in order to protect himself from farther inroads by Mr. Heaton.

Some tests have recently been made by Mr. Kirkaldy on a steel said to be Heaton's, the result being very uniform, and showing 23 tons tensile strength and 20 to 28 per cent. elongation in breaking. Mr. Heaton states that a remelted tool steel in one-half inch bars, from very impure Cleveland pig, stood above 53 tons. Some of the London authorities do not believe that these tests were made on the Heaton steel. Mr. Heaton's statements conflict with other statements previously published by witnesses of the process, and by the analyst of the product. Until the doubts thus thrown upon the process are explained away, it is impossible to believe that Mr. Heaton has as yet made any great advance in the manufacture of cheap iron and steel. We do not think, however, with some of our contemporaries, that the process is of no value because ironmakers have not yet taken it up. It is also possible that there is value in the nitrates as purifying agents. If so, it should appear that Mr. Bessemer's mode of applying them, described in the last number of this magazine, is more reasonable and hopeful than Mr. Heaton's.

*See Van Nostrand's Magazine, Vol. I., No. 1, page 77.

Engineering in the Mississippi Valley.—General Roberts, U. S. A., sets forth in a remarkable paper, that the dyking of the Mississippi is obstructing the creative laws of delta bottoms, by emptying into the Gulf the material that if spread over the land would improve its quality and raise its level. He proposes to feed the Mississippi from the great Lakes, by way of the Rum River and the Illinois River, and connecting canals, and to feed the Ohio from Lake Erie, by way of the Beaver River.

THE MONT CENIS TUNNEL.

PROGRESS OF THE WORK—ENGINEERING DIFFICULTIES—THE BORING MACHINES.

Perhaps no work ever undertaken by men was more daring than the attempt to pierce the Alps with a tunnel. Nature seems to have upreared these mighty barriers as if with the design of showing man how weak he is in her presence. Even the armies of Hannibal and Napoleon seemed all but powerless in the face of these vast natural fastnesses. But the barrier which man had scaled of old, he has now undertaken to pierce. And the work, bold as it seemed, is three parts finished.

The Mont Cenis Tunnel was sanctioned by the Sardinian government in 1857, and arrangements were made for fixing the perforating machinery in the years 1858 and 1859. But the work was not actually commenced until November, 1860. The tunnel—which will be fully 7½ miles in length—was to be completed in 25 years. The entrance to the tunnel on the side of France is near the little village of Fourneau, and lies 3,946 feet above the level of the sea. The entrance on the side of Italy is in a deep valley at Bardoneche, and lies 4,380 feet above the sea level. Thus there is a difference of level of 434 feet. But the tunnel will actually rise 445 feet above the level of the French end, attaining its height at a distance of about 4 miles from that extremity; in the remaining 3¾ miles there will be a fall of only 10 feet, so that this part of the line will be practically level.

The rocks through which the excavations have been made are for the most part very difficult to work, and largely consist of crystalized calcareous schist, much broken and contorted; through this rock run in every direction large masses of pure quartz. The perforating machines are calculated to work best when the resistance is uniform; and it has often happened that the unequal resistance offered has resulted in injury to the chisels.

But before the work of perforating began, enormous difficulties had to be contended with. It will be understood that in a tunnel of such vast length, it was necessary that the perforating processes carried on from the two ends should be directed with the most perfect accuracy. It has often happened in short tunnels that a considerable but not fatal want of coincidence has existed between the two halves of the work, but in the Mont Cenis tunnel any inaccuracy of direction would have been fatal to the success of the work, since when the two tunnels should meet it might be found that they were laterally separated by two or three hundred yards. Hence "it was necessary," says the narrative of the official survey, "to prepare accurate plans and sections for the determination of the levels, to fix the axis of the tunnel, and to 'set it out' on the mountain top; to erect observatories and guiding signals, solid, substantial, and true."

When we remember the nature of the passes over the Cenis, we can conceive the difficulty of setting out a line of this sort over the Alpine range. The necessity of continually climbing over rocks, ravines, and precipices in passing from station to station, were as nothing when compared with the difficulties resulting from the bitter weather experienced on those rugged mountain heights. The tempests which sweep the Alpine passes—the ever-recurring storms of rain, sleet, and driving snow, are trying to the ordinary traveller; how terribly they must have interfered with the delicate processes involved in surveying. It often happened that for days together no work of any sort could be done, owing to the impossibility of using levels and theodolites. At length, however, the work was completed, and that with such success that the greatest deviation from exactitude was less than a single foot for the whole length of seven and a half miles. Equally remarkable and extensive were the labors connected with the preparatory works. New and solid roads, bridges, canals, magazines, workshops, forges, furnaces, and machinery had to be constructed; residences had to be built for the men, and offices for the engineers; in fact, at each extremity of the tunnel a complete establishment had to be formed.

According to the latest advices the work proceeds at a rate fully equalling the original expectations of the engineers. Of 12,220 metres—the total length of the tunnel—no less than 8,958 have been completed. It is hoped that the remaining 3,262 metres will be completed early in the year 1871.—*Railway Record.*

With regard to the machines used in driving the tunnel, each is formed of a pair of bars, about 6 feet long, having between them the 3-inch cylinder by the piston of which the boring tool is actuated. The cylinder is not fixed to the frame-bars, but is capable of sliding on them, motion being given to it by a large worm at its hind end, which gears into racks formed on the inner sides of the frame bars. The cylinder is 3 inches in diameter, and its piston has a rod about 2 inches in diameter, there being thus but a comparatively small annular area on the front of the piston on which the air continually presses. At the hind end of the frame-bars of the machine is placed a miniature engine, worked by compressed air — this engine driving, through a bevel gear, a square shaft, which extends nearly the whole length of the machine above the boring cylinder. This shaft, by means of a cam, drives the slide-valve of the boring cylinder, and also gives intermittent rotary motion to the tool, and also the necessary advance to the cylinder as the hole is bored. By an ingenious automatic device, the worm is thrown out of gear when the cylinder cannot advance by reason of the hardness of the rock. Each boring machine weighs about 6 cwt., and as the wear and tear to which they are exposed is very severe, it is found necessary to keep from three to four machines in reserve for each one at work.

The boring bars are of various forms and diameters. The Z and double Z or crown borers are those most used, but for some kinds of rock other forms are found preferable. The holes are generally about $1\frac{1}{4}$ inch. in diameter. In working through some of the very hard quartz it was found that the shots flew back from the ordinary holes without producing any disruptive effect on the rock, and the plan was therefore adopted of first boring several holes 4 inches or 5 inches in diameter, and then disposing some ordinary holes round these. When the charges in the ordinary holes were fired, the portions of the rock between them and the central hole were blown out, and a cavity thus formed, around which other shot holes were bored. The borers used for the 4-inch and 5-inch holes are of similar form to smaller bars, and, like them, they are worked by the boring machines, but at a slower speed.—*Mining Journal.*

The line is now worked by a temporary railway (referred to in another column) over the mountain. This road is 48 miles long, passing over a summit nearly 6,000 feet above the sea, and has long stretches of gradients of 1 in 12, and curves of two chains radius. The gauge is 3 feet $7\frac{1}{2}$ inches.

LOCOMOTIVES OF THE METROPOLITAN RAILWAY.

Very different types of engines are required on the various lines in, about, and under London, but the conditions do not seem to have been equally well met by the different locomotive superintendents. On the North London, the passenger business is large, but the goods traffic is immense. Trains weighing over 400 tons are frequently run with, and compelled to keep out of the way of passenger trains. All the new engines are designed to work goods and passenger traffic alike, and they are, therefore, of the most powerful class, weighing 43 tons, and fitted with 17-inch cylinders, 24-inch stroke, and caring 160 pounds pressure. They perform their duties admirably, and it is difficult to see how they could be improved upon.

The engines of the underground railway have the Bissell bogies, which appear to answer their purpose very well. Whether it is or is not possible to dispense with bogies it is not easy to say, as the underground line affords very conflicting testimony. The engines of the Midland Company, to work their city traffic, are very similar to the standard type, with the exception that they have 6 instead of 8 weels; but their use has been protested against by the engineers of the Metropolitan line, on the ground that, owing to the comparatively long and rigid wheel base, they injure the permanent way. On the other hand, Mr. Fowler designed 6 coupled engines without bogies to work the St. John's Wood traffic, from which we gather that he did not deem a flexible wheel base essential; these engines, however, are more often found standing in their sheds than running. The Great Western Company, too, have introduced 6 coupled, 4-feet broad gauge drivers without bogies, which work regularly and give satisfaction. All the engines we have named are remarkable for the facility with which they start their trains and the shortness of the distance within which they attain their maximum velocity.

The Metropolitan Extension is worked by 3 different types of engines. One class, weighing 33 tons, has 6 wheels, 4 coupled, 16-inch cylinders, 22-inch stroke, and 5 feet 6 inch drivers. The trailing wheels are placed directly under a large tank, and fitted with Mr. W. B. Adams' radial axle boxes. These engines are used alike by the Great Northern, and the London, Chatham, and Dover Company. Both classes are run with either end leading, and for this kind of work they are not the best. The radial axle box is not well adapted for leading wheels, and the engines oscillate very much when running tank-end first. A greater defect lies in the fact that the tanks are so high that the drivers cannot see over them. This latter evil was felt so severely in the case of the London, Chatham, and Dover engines, that Mr. Martley has recently cut 1 foot or 18 inches off them with great advantage.

The next type of engine has side tanks and 6 wheels, 4 being coupled with 15-inch cylinders, 22-inch stroke, and 5 feet 6 inch drivers. They are good little engines, run steadily, and cost little for repairs; thanks principally to the considerable dimensions given to the machinery, which is unusually heavy in proportion to the diameter of the cylinders.

Lastly, the Metropolitan Extension is worked by small tank engines with outside cylinders, 15 inches diameter, and 22-inch stroke; 6 wheels, 4 coupled, and Beattie's patent boiler and fuel-heating apparatus. They are, in some respects, the best engines on the line. Though small, they get away quickly with their trains, make an abundance of steam, and are essentially more "lively" than any of their rivals. None of these engines appear, however, to be the best that could be adopted in working this line; they are all too large and heavy for the slow speed adopted on this line. With the exception of short inclines at the ends, the road is nearly level, and according to modern notions, without expressively sharp curves.—*The Engineer.*

ACCUMULATOR COTTON PRESS.

From a paper by Mr. Baldwin Latham, read before the Society of Engineers, Dec. 7.

While the cotton culture in India was in its infancy, the quantity produced was too small to create a demand for any special baling apparatus. Machines were sent out from England, but they were of a very primitive kind. Screw presses, something like those used for making cheese, were contrived. The next step was to work the vertical screws by bevel gearing and a winch. Then, as the cotton trade grew in importance, there was devised a number of inventions and contrivances, some by engineers and others by the cotton growers, whose ingenuity was stimulated by necessity. Levers, screws, and wedges were tried alone and in combination. The use of hydraulic pressure naturally suggested itself for trial, but it was not very successful; no very great power was obtained, and the process by pumping was slow. Gradually, improvements were made in the lever presses, and these were generally preferred. Some of them may be mentioned. A Mr. McComb took great pains to make a good baling machine, and patented several of his improvements. His cotton was forced up by two compound levers, drawn together by a chain worked by hand or steam.

Mason's press had somewhat the same principle of levers, but was worked in a different way. A horizontal engine drove 2 machines, the crank-shaft running right and left from the engine. By gearing, a shaft parallel to the crank shaft was driven at a reduced speed, and by means of right and left-hand screws on these shafts 2 powerful levers were drawn together and forced upwards against the follower of the cotton box. Both these presses are still in favor, and are used in considerable numbers. Hodgart's press embodies a very ingenious combination of hydraulic and lever powers. The process by pumping being in ordinary presses slow, it was here endeavored to reduce the quantity of water necessary to be pumped by having a ram of small area, and by multiplying the power so gained by the levers. This press, at its usual rate of speed, will pack 10 bales per hour, and it is possible to do 14; but this is too severe labor for the men. At the time of the Abyssinian expedition, hay was packed for the troops at the rate of 15 bales per hour; but this was an exceptional and extraordinary speed.

The Bombay Press Company uses Nasmyth's press, which is one of the best that has yet been invented. The pressure is effected by 3 hydraulic rams placed side by side. At the beginning of the stroke, while the cotton is in a pliable state, the power is applied by 1 cylinder only. Towards the end of the stroke, the other 2 rams are also set in motion, the 2 cylinders having been filled with water, so as to save time in pumping when the power is applied to them.

There are in America a vast number of inventions for all processes connected with cotton. Levers and screws, hydraulic and steam pressure, have been combined in many different ways, and with varying success. Wood is more used in America than in England in the construction of machines, and machines so made would not probably find favor elsewhere. Very likely English machines would be condemned there. As one of the incidents arising out of the war, when the Southern ports were shut out from the rest of the States, the blockade runners took over English made presses, and among others some of McComb's, but they found no purchasers. Every other detail of cotton packing is studied by inventors in the States, and the correspondent before referred to, says that there are some fifty different patents even for modes of fastening the baling hoops.

Mr. George Ashcroft has patented a machine in which he obtained the power of hydraulic pressure combined with rapidity. The first and easy pressure on the cotton was rapidly effected by a steam piston, only the final and severe pressure being given by a hydraulic ram. This press worked satisfactorily, and would probably have been pushed to success by the inventor had he not thought of something better, viz.: the application of the accumulator.

While in theory there is no limit to the force that can be exerted by hydraulic pressure, in practice the difficulties commence at a certain point. A maximum pressure of 2 tons to the square inch has been employed; but then it is necessary to have a large area of ram to obtain the required total, and to get this with 1 cylinder involves practical difficulties, which increase very rapidly with the diameter of the cylinder, viz., the risk of spongy castings and parts inconveniently heavy and difficult to transport. In Mr. Ashcroft's invention, the required area is obtained by placing 3 cylinders with 8-inch rams side by side, and these giving a total area of 150 inches, a force of 300 tons is produced.

The box in which the cotton is pressed is made entirely of wrought-iron, strongly framed, and the upper part of it, where the ultimate pressure is received, is of considerable thickness. This part of the box is planed all over, so as to present a true and smooth surface to the cotton. The doors are made so that 3 of the 4 sides can open. The "accumulator" is of the well known simple kind, consisting of a cylinder and ram, the latter supporting a weight box which moves up and down in guides. The 3 hydraulic pumps of equal size are driven by a pair of horizontal engines.

The mode of working is as follows: The house consists of a ground floor and two floors above. Upon the ground floor are fixed the steam-engine, the pumps, the press, and the accumulator cylinder. The framework of the press reaches through the floor to the top of the chamber above. In the uppermost chamber the loose cotton is stored. On the centre floor are the handles for working the valves. During the whole time of pressing and baling the cotton, the engines and pumps are at work. The accumulator box is forced up with a pressure of less than 1 ton to the inch. The men upon the top floor having placed the bagging in the box, and filled it with loose cotton, which they trample down, the men below push round the revolving boxes (a special feature of the invention), so that the cotton-filled box is over the rams. The boxes revolve upon a strong vertical column, the weight being taken on balls, which rest upon a collar. A portion of the floor revolves with the boxes.

The hooping irons having been placed in recesses at the top of the press, the engineer opens the valve which admits the high-pressure water to the rams. At once the accumulator descends, and the 3 rams of the press ascend, forcing the loose bottom of the box upon the cotton. But as the accumulator descends the pumps being still at work, they, in some measure, restore the height of the water column, and the accumulator ram gently ascends and descends as the water is thus withdrawn and restored. When the cotton is compressed upwards as tightly as the rams can force it, the engineer shuts the valve which admits the water from the accumulator and the pumps, and opens one which admits the water from the differential cylinder. By means of rams of different diameters, the pressure given by the pumps is in this cylinder multiplied. The superior power thus produced forces up the 3 rams, and with them the cotton, the last few inches of the stroke to the ultimate point desired. One of the doors of the box is then opened, the hoops are fastened, and then the other doors being opened, the water in the cylinders is let to waste, and the rams descend. The elastic cotton at once expands into the small distance allowed by the hoops, and with but slight assistance from the workmen the bale tumbles from the box and falls down a shoot to the floor below. Meanwhile the other box having been filled with cotton, it is pushed round into its place over the rams, and is in its turn subjected to the pressure of the water, and so the process is repeated without intermission.

The principle of the accumulator is well known, and for working cranes, opening dock gates, and many other purposes, has been in operation some time. It is probable that sooner or later some one would have applied it to baling presses, but at any rate Mr. Ashcroft has done it, and he only. Among the merits claimed for this machine are the following: The simplicity and smoothness of the process obviates the excessive wear and tear which is unavoidable in machines where the pressure is obtained by levers or screws. The friction on the packing leathers is extremely small. Great uncertainty existed until recently on this point, and all makers of hydraulic presses differed from each other on the subject. Professor Rankine gave 10 per cent. of the total load as the amount wasted by the friction of the leathers, but the whole question has been most successfully investigated by Mr. Hicks, of Bolton, who by his experiments, which are recorded in his admirable little treatise published last year, proves that the friction of the leathers on an 8-inch ram is about $\frac{1}{200}$ part of the total load, the decimal varying from .003 to .005 according as the leathers are more or less worn, and well or sparingly lubricated.

The revolving boxes are an ingenious part of the machine, and by their arrangement obviously save much time. Twenty-five or more bales can be packed and hooped per hour. In Alexandria the accumulator press is in full operation, and at Bombay also it is exciting much interest among the cotton merchants, some of whom are now in treaty with a view to its adoption there.

THE SUEZ CANAL.

From a letter to the London "Times," by Captain Macgregor, of canoe "Rob Roy" fame, we extract the following interesting facts and impressions: The Suez Canal Company have been fourteen years at work upon their gigantic labor, and they announce positively that the canal will be opened within a year from the present time (November, 1868). The canal is to be 100 miles long, and 328 feet wide (at the water's edge). The depth throughout will be 26 feet in the middle. The direction is nearly north and south, with a few turnings, but no locks or bridges. There will be a slight tidal current along it, but no one can say at what intervals. Already about 50 miles of the cut is filled with salt water, and is traversed daily by numerous small vessels and some steam-launches and mailboats. The sensation of wonder at the prodigious scale of the operations in progress increases day by day as one moves along what seems to be a wide river, with villages on the banks and smoky funnels and white sails on the surface. Of this 50 miles many parts are not wide enough yet for large vessels, and only a small portion is excavated to the full depth. The remainder of the canal is more or less dug out. While some parts are quite dry, others are put under water to moisten the sand; others have great blastings of rocks, and one long section of 20 miles has to wait until the sea is admitted into the great dry basin of the future lake.

The dredging machines are 40 in number, and each of them cost £40,000 (?). They deliver the sand to barges to be carried out to sea, or pile it upon the banks, in some places to a height of 50 feet. The expenses at present amount to £200,000 every month, and the work has already absorbed £8,000,000 sterling.

Port Said, the town at the north entrance of the canal, is built of wood, with wide, straight streets, and accommodates 6,000 people of every nation, but with the Greek and Levantine element largely preponderating. The two long piers that form the harbor are made of blocks of sand, cemented with lime (concrete); each block weighs 10 tons, and there are 25,000 of them.

Ismailia is a pretty town half-way along the canal, which here enters the Lake Timsah. Here the Arabs and their camels and the jackals of the Desert are alongside the steamboats, the whirring lathes and sounding forge-hammers of the company's workshops. A fresh-water canal comes hither all the way from Cairo, and then branches out north and south along the whole extent of the salt-water canal. The sweet-water canal is already a blessing to Egypt. It is from 30 to 40 feet wide, and boats with all sorts of cargoes are towed or sail through it.

During one day a violent gale swept across the canal. To look at the Desert was to see a vast yellow picture of men and camels dimly floating in a sea of sand without any horizon. The quantity of sand, whisked from the plain and cast into the canal-water by a wind like this will be a serious matter to deal with. One ounce of sand per square yard amounts to 500 tons on the whole canal, and the wind sometimes blows in this way for a month together.

At Chaloof I found 14,000 men at work. They labor very hard, indeed, running up the hill with baskets of sand on their heads. About 1,000 donkeys walk in long lines with neat mat baskets on their backs. In curious and close contrast to these simple carriers the mighty power of steam toils and puffs as it hurls up huge bulks of heavy clay, and it is, perhaps, only in Egypt one could see human and animal power exerted in such competition with steam power. The laborers are sent from all parts of Egypt. They must come, but they are highly paid—from 2 francs to 3 francs a day. Prices, both of labor and of food, have risen very much since the canal has been begun, but the supply of fish has rapidly increased. The salt water canal teems with fish.

At this, the Red Sea end, the works of the canal seem very far behind. The entrance port has all the obstacles of a shallow mouth, soft and shifting sand for bottom, and a crooked irregular tide eddying about in a most puzzling way.

When the passage from the Mediterranean to the Red Sea is open to the world it is intended to tow vessels through by tug boats working along a chain which lies at the bottom of the water. Steamers are not to be allowed to use their own paddles or engines for fear of damaging the soft sloping banks of the canal by the "wash" thus created. The difficulty of towing a vessel of 2,000 tons in this manner when the wind presses her to one side is an objection to which I have heard no feasible answer.

THE ITALIAN TECHNICAL COLLEGE of commerce is now organized, and will be opened immediately under the direction of Signor Farrara, a distinguished Sicilian gentleman, lately Minister of Public Instruction. This institution is chiefly intended for young men destined for the Consular service and for mercantile pursuits. The principal languages of Europe and the East, the various systems of banking, the principles of commerce, of exchange, of book-keeping, and of commercial law will be taught in it. The Venetian Provinces contribute toward its maintenance 40,000 francs a year; the city of Venice, the magnificent Foscari Palace and 20,000 francs a year; the Chamber of Commerce, 8,000 francs; and the Government, 10,000 francs.

THE KIRBY REAPER FACTORY of D. M. Osborne & Co., Auburn, N. Y., comprises 8 large buildings, employs 300 men, and turned out 5,300 reapers in 1868.

WORKING THE SOLAR RAYS.

The possibility—we are inclined on general principles, to say the probability—of utilizing the direct heat of the sun, as proposed by Capt. Ericsson, is the grandest scheme that science has presented to man. It should almost appear that the Creator has laid up a little condensed heat in the coal mines for our use during our school-time; a little condensed milk for our babyhood in science; and that when we are grown and learned, we shall draw power from its original fountain. The facts regarding the heat of the sun, as quoted and developed by Capt. Ericsson, together with the recently acquired and equally startling knowledge, that our garnered stores of power are not as eternal as the hills, render such a conclusion reasonable and hopeful.

Capt. Ericsson has not yet told us *how* he concentrates the solar rays, but promises to do so in due time; meanwhile, the experiments and conclusions referred to are interesting and may be thus briefly stated.

Sir John Herschel's experiments relating to solar heat, were conducted at the Cape of Good Hope. His apparatus consisted of a tin vessel $3\frac{3}{4}$ inches diameter, $2\frac{1}{2}$ inches deep, open at the top, and partially filled with water darkened with ink. This was exposed to the immediate action of the rays of the sun in a stationary position for 10 minutes. The amount of radiant heat communicated was deduced from the increase of temperature of the water during the 10 minutes' exposure to the oblique rays. Owing to changes in the atmosphere, the elevation of temperature was not quite alike at each trial. Adopting the mean, he calculates that, near the earth's surface, the energy of the sun is such that the radiant heat is capable of melting an inch thickness of ice in 2 hours, 12 minutes, 42 seconds.

M. Pouillet's experiments relating to solar heat, like those of Sir John Herschel, had reference only to very low temperatures, the range of the thermometer scarcely reaching 60° C. The apparatus he employed was very similar to that of Herschel. It consisted of a cylindrical vessel of silver, 1 decimetre in diameter and 15 millimetres in depth; but being provided with a close top, it admitted of being fully charged with water, besides admitting of an inclined position, which permitted the rays to act perpendicularly on the blackened metallic surface. The disadvantages attending oblique action, not to mention the intricate question of *evaporation* during the trial, were thus avoided. A thermometer was inserted in the fluid, and means provided for proper agitation during the trial. The exposure to the sun was limited to 5 minutes, and the elevation of temperature during that brief time formed the basis of all his calculations.

These experiments, although interesting, are not satisfactory, as they deal with low temperatures. The purpose of Capt. Ericsson, on the other hand, has been to ascertain what amount of heat can be developed at the high temperature obtained by concentrating the solar rays, viz., bringing their power to bear on a reduced surface, and to devise the most efficient means for effecting such a concentration of the radiating heat. His experiments made under temperatures varying between 212° and 480°, and continued during nearly a year, tend to show that the problem cannot be solved by 5 and 10 minutes' trials restricted to temperatures some half-dozen degrees above that of the atmosphere. The results recorded by Pouillet, reveal discrepancies pointing to atmospheric influence, which, when properly understood, will modify the conclusions hitherto so confidently drawn.

Regarding the main result of the investigations of Herschel and Pouillet there can be no doubt. A body presenting a square foot of surface perpendicularly to the sun at noon, during summer, will, under favorable circumstances, receive about 5 units of heat per minute. This fact Capt. Ericsson has fully proved by concentrating the radiant heat of sunbeams of various sections from 650 to 5,180 square inches, hence fully 500 times more powerful than the sunbeams to which the "actinometer" and "pyrheliometer" have been exposed.

Investigations conducted only during the *summer* being insufficient to settle the important question, Capt. Ericsson is making a series of experiments this winter, with instruments so contrived that the loss of heat by radiation will be almost inappreciable. It is hoped, therefore, that a satisfactory explanation of existing discrepancies will be furnished. In order to facilitate these investigations, a small observatory has been erected over a building some 60 feet above ground, turning on a pivot by mechanism resembling that of a monitor turret. Still further to facilitate the work, the tables which support the instruments have been provided with mechanism by which they are kept perpendicular to the central ray of the sun during the experiments.

Capt. Ericsson's conclusions as to the power of the sun's rays are as follows: At the high temperature requisite for steam-engines, the heating power of the sun on a surface of 10 feet square will evaporate on an average 489 cubic inches of water per hour, by means of his mechanical contrivance for effecting the necessary concentration. This evaporation demonstrates the presence of sufficient heat to develop a force capable of lifting 35,000 pounds 1 foot high in a minute, thus exceeding 1-horse power.

The mean distance from the centre of the sun to the earth being 214.44 times greater than the radius of the former, it will be found by squaring this sum that 1 superficial foot of the sun's surface must heat 45,984 superficial feet of the earth. In other words, the sun on an equal surface throws off 45,984 times more heat than the earth receives. We are therefore enabled, on the strength of the practical result now positively established, to infer that an area of 10 feet square on the sun's surface developes heat enough to actuate a steam-engine of 45,984-horse power, demanding a consumption of more than 100,000 pounds of coal every hour. But as one-half of the heat conveyed by the solar rays is lost during their passage through the atmosphere and through the apparatus by which the temperature is elevated to the necessary high degree, the actual development of heat, on the supposed 10 feet square of the surface of the sun, will therefore equal the amount of heat generated by the consumption of 200,000 pounds of coal per hour.

In pointing out what amount of mechanical power may be obtained by occupying a Swedish square mile with solar engines, Capt. Ericsson assumes that one-half of the area is set aside for necessary roads, houses, etc., an available area would remain of $18,000 \times 36,000 = 648,$-000,000 superficial feet on which the radiant heat might be concentrated. His experiments having shown that the concentration of the solar heat on 100 square feet of surface is more than sufficient to develop a horse power, it follows that 64,800 engines, each of 100-horse power, may be kept in motion by the radiant heat of the sun on a square mile, or that the sun's rays which now waste their strength on the house-roofs of Philadelphia, would be able, if condensed, to set in motion 5,000 steam-engines, each of 20-horse power.

As to practical results Capt. Ericsson says: It is true, that the solar heat is often prevented from reaching the earth. On the other hand, the skillful engineer knows many ways of laying up a supply when the sky is clear and that great store-house is opened where the fuel may be obtained free of cost and transportation. At the same time a great portion of our planet enjoys perpetual sunshine. Capt. Ericsson had at the beginning of the last year constructed 3 different motors, called *solar engines*. One of these is actuated by steam formed by the concentration of the heat of the solar rays, while the other 2 are actuated by the expansive force of atmospheric air, heated directly by concentrated radiant heat. Some of his more recent experimental engines, the working cylinders of which vary from 2 inches diameter to 5 inches diameter with 6 inches stroke, are operated by atmospheric air heated to a temperature of 480° by concentrating the sun's rays; others are operated by steam of much lower temperature generated likewise by concentrating the radiant heat. The speed attained has in no case been less than 100 revolutions per minute, while a regular and continuous rate of 300 revolutions per minute has been reached. The construction of these experimental engines, present no features of special novelty. The mechanism, however, adopted for concentrating and transmitting the solar energy to their working pistons, is peculiar, and at the proper times, plans and descriptions will be published.

Excelsior Machine Works, Chicago.—These works employ 75 men on wood work and wood working machinery. The principal building is 270×60 feet.

The Charleston Phosphates.—The "New York Tribune" of Dec. 19, has an exhaustive article on the history and utilization of this important discovery. The "fish bed of the Charleston basin," so called because of the remains of marine animals found in immense quantities there, crops out on the banks of the Ashley river near its mouth, and on various neighboring rivers, and extends inward 40 or 50 miles. The marl or conglomerate of this basin is already ascertained to be 12 feet deep in some places, and to contain as much as 67 per cent. of phosphate of lime in some instances. Although its existence had long been known, its value was not ascertained till after the war, and even then it was difficult to enlist Southern capital in it. The necessary aid was obtained in Philadelphia, and now 5 companies with ample capital are mining the rock, and manufacturing the phosphates for agricultural purposes. The credit of discovering the value of the deposit, and of persistently calling attention to it, seems to be due to Dr. N. A. Pratt of Charleston.

Temperatures of various substances, superheated steam for instance, may often be conveniently ascertained by the melting points of alloys. The following are the fusing temperatures of various alloys of lead and tin:

Lead.	Tin.	Centigrade.	Fahrenheit.
7 parts.	4 parts.	213°	416°
7½ "	4 "	221	430
8 "	4 "	225	437
8½ "	4 "	232	455
10 "	4 "	241	466
14 "	4 "	252	484
19 "	4 "	262	504
30 "	4 "	274	524
48 "	4 "	275	544
55 "	4 "	289	553

Linseed oil boils at 312.40°.
Lead melts at 319°.

Schools in Chicago.—They are as follows: a high school, 21 grammar, and 6 primary schools, which are public; also some 50 private grammar schools, various Roman Catholic, medical and law schools, and the Chicago University. The number of scholars in the public schools in 1867, was 30,000, the total cost per scholar, $23.84, the number of teachers 401, the value of public school buildings $800,000.

COMMUNICATION BETWEEN ENGLAND AND FRANCE.

A new impulse has been given to this ever-recurring question, by the fact that a French port was recently unable to give shelter to a mail steamer bound for the shores of that country, and which, after beating about the Channel for twelve hours, was compelled to return to the harbor from which it started. The various plans put forward for better communication, are classed by the "Mechanics' Magazine" under one of three heads —submarine, transmarine, and supermarine. Under the first are included the tunnel and the tubular projects, the difference between them being that the tunnel whether of iron, masonry, or brickwork, must be placed in the earth, whereas the earth must be piled around and on top of the tube. The tunnel must be excavated or laid under the earth; the tube lies along the surface constituting the bed of the Channel. The object of the covering of earth over the tube in either instance is the same, viz., to preserve the top from being injured by ships' anchors, dredgers, sunken vessels, or other external disturbances. Of these two methods, the tube would probably have the advantage in point of time, but great difficulty would attend the junction of the several lengths. The transmarine classification embraces two plans,—that of a solid embankment and that of a gigantic ferry. A solid embankment, as it must be sufficiently high to be above the level of the greatest wave, partakes of the nature of the third class, and might also with propriety be termed intramarine. This plan is altogether Utopian. Neglecting aerial means of transit, a bridge is the sole representative of the third category.

The objections to the tunnel and tube are, the unsubstantial character of the scheme, the complete uncertainty of the time to be occupied in its construction, and the total want of precedent. Assuming that everything proceeded as favorably as possible, it would take nearly twenty years to finish the job, calculating that the rate of progress could not be greater than that at present obtained at Mont Cenis. On this subject "Engineering" says: "Setting aside the difficulties of such a work, the inextricable complications which would arise between the two countries in the event of the peaceable relations between France and England being interrupted, and the precarious length of life of the tunnel if completed, the length of time its construction would involve, the enormous outlay of capital, and the enormous loss upon locked-up money lying idle during the formation of the work,—each of these reasons is sufficient to dispose of the tunnel question forever. Moreover, during the 20 or 30 years such a scheme would require for completion, the necessities of the increasing traffic would certainly be satisfactorily accommodated, and the millions expended upon the tunnel would have been literally thrown into the sea."

The ferry scheme of Mr. John Fowler is as follows: It is proposed to construct at Dover a harbor of about 24 acres extent, protected on the east by the old pier, and on the south by a new pier carrying a railway. A suitable harbor would be constructed at Calais or more probably near Cape Griz Nez, where there is deeper water. The vessels to be 450 feet by 85 feet over all, and 53 feet beam, and to draw 12 feet. The engines to be 1,200 nominal horse-power, and the speed some 20 miles an hour. The trains are to be run bodily upon the boats, as in the American system. Four vessels, costing £120,000 each, are contemplated. Of this scheme the "Mechanic's Magazine" says: What is required is a connecting link between the two shores which is totally independent of the intermediate barrier, and this result is manifestly not obtained by the agency of a ferry. It is an alteration of the present arrangement in degree only, not in kind. For a time it would be considered a great boon, but so soon as the novelty had worn off, the feeling would arise that it was, after all, but a makeshift—a temporary expedient—and we should return to the reconsideration of the more permanent systems now claiming public attention.

Of the bridge scheme, the same authority says: Allowing about 1,000 feet for the width of the spaces, they would be, in round numbers, double those of the Britannia Bridge, while the height of the piers above high water would be but a mere trifle in excess of the Britannia piers. Every engineer will admit that the difficulty is not in the superstructure, but in the foundations ; but from the result of borings recently made, the substratum appears to be favorable to their being got in. And whatever circumstances of foundation and soil favor the construction of a tunnel, are doubly advantageous to that of the bridge, and, consequently, if no difficulty is to be experienced in that respect for the tunnel, the argument against the difficulty of getting in the piers falls to the ground. When lighthouses, constructed entirely of iron, and supported upon iron piles, have been erected far out at sea, it is absurd to talk of the great and almost insuperable difficulty of getting in foundations elsewhere in similar situations. Besides, it would not be all the piers that would give the same degree of trouble, but only those situated remotely from either shore. Another advantage of a bridge would be that its construction and its utilization could proceed *pari passu,* and there would be no necessity for waiting for its completion, as in the case of a tunnel, before its services could be availed of. As each successive span commencing from the shores was finished, it could be used as a jetty, and year by year the opposite coasts would be in closer contiguity. In adopting the project of a bridge, there is not the slightest necessity for departing from any of the recognized types of construction, either in the sub or superstructure.

The proposal lately put forward by a French engineer, Boutet—and given place to in such publications as the "Journal of the Society of Arts" and the "Pall Mall Gazette"—the scheme of floating foundations and spans of a couple of miles, is simply a chimera, and would not stand the test of theoretical, much less practical analysis. M. Boutet, says "Engineering," "proposes to cross the Channel from the Shakspeare Cliff to Cape Blanc Nez, by a bridge with 10 openings, or clear spans, each 3,282 yards long, the platform of which is to be 360 feet above the average sea level. He proposes to construct his 9 iron piers upon the shore, to float them into place, fastening them to the bottom with screw-piles, and covering the structure with gutta-percha to prevent the adhesion of barnacles and the deterioration of salt water. And he proposes to lay out the course of the bridge to which the piers are to be hauled and sunk, by a buoyed rope, stretched from France to England. From this range of stupendous summits, nearly two miles asunder, M. Boutet stretches cables 2 inches in diameter, and of iron, not steel ; from 30 to 120 of these cables are ranged vertically 20 inches apart, the larger number over the piers being reduced to the lesser in the centre of the span. The cables are woven together with smaller diagonal wire ropes, and cast iron is thrown in when it is of no service, because, we presume, it looks well in the drawing, and gives an air of security to the flimsy web. The lower side of this "tress," as the projector terms it, is curved, but there is no compression member designed, and, moreover, none *could* be designed which should resist the enormous strain of the structure, and give the only value which could be given to the rest of the clumsy contrivance. More than that—and this is a point which the dullest disciple of Boutet can understand—the projector proposes to give rise to these trusses of 6 in 1,000, and so to obtain an increased rigidity. Now, it is absolutely impossible to stretch a wire between two points, however close they may be together, without deflection, because the strain required to do so is infinite, and in such an extreme case as M. Boutet proposes, the cables would break from their own weight long before any approximation to a horizontal line was obtained. In fact, allowing the extreme amount of strength to his cables, and assuming that they could be made perfectly homogeneous throughout, it will be found that the strands would part in the centre before they were within 500 feet of a horizontal line, in other words, the point of rupture would be attained when the cables had still to be hauled up 500 feet to get them into position."

Some reasonable sort of bridge, however, would appear to be the only feasible continuous work that could be built. It would cost perhaps twice as much as a tunnel—the rule of cost is stated to be three times as much for bridges as for tunnels—but it would be completed in a reasonable time. Thousands of men could work upon it, while tens of men were at work on a tunnel.

But before the bridge question is settled, years before the bridge is completed, the comfort of millions of passengers is to be secured, and the transhipment of millions of packages of goods avoided, at a comparatively small expense, by the running of suitable boats between England and France. Undoubtedly the ferry system, however complete, will be inadequate 10 or 20 years hence; but during that period there should be at least as decent, comfortable, and economical communication as there is, for instance, between New York and Newport—a longer, and in parts more exposed route than that across the Channel.

Lead in Tin Vessels.—A report has been published on the tin and tinned vessels used in the military hospitals in France. The metal used for tinning, it was found, contained from 25 to 50 per cent. of lead. In vessels reputedly made of pure tin, the Commissioner found, in some cases, as much as 15 per cent. of lead. Such proportions are dangerous, he says, to the public health, and the Government is recommended to fix a standard allowing only 5 or 6 per cent. of lead to be used with tin in utensils intended for culinary purposes, or for drinking-vessels. The author has probably over stated the dangers from the use of utensils composed as he has found; but it would be well if cheap manufacturers in this country would bear in mind that it is not altogether safe to use a large proportion of lead.

Explosions in gas works, and in buildings where gas is leaking, as well as in mines, may be prevented by the use of the Davy lamp. Explosions are often caused in dwellings, by looking for leaks in meters and pipes with an uncovered lamp. At New Village, Mass., five men were recently killed by the explosion of a gas holder which they were repairing. The Davy or the Strive safety-lamp should be kept ready for use in gas works, and in all large buildings, such as hotels and theatres, where gas leaks are likely to occur.

Pratt, Whitney & Co.'s Machine Works, Hartford, Conn.—The machine shop is 220×45 feet, 3 stories, and employs 150 men. Machinery to turn out 500 rifles per day has recently been completed for Austria.

CONCREVE BUILDINGS.

Compiled from the "American Artizan," "The Engineer," etc.

The increased cost of building materials, has of late led to renewed and extensive experiments with concrete. This material has in various forms been employed for ages, and is said by travellers to be found hard and undissolved after 3,000 years of exposure among the temple ruins of Nineveh.

This concrete was in all probability composed simply of a lime mortar, tempered by treading with the naked feet of the laborers until it became tough and homogeneous, and then mixed with broken stone or rubble.

Many attempts have been made in this country to use a material of this character in the construction of buildings, but owing to the slight degree to which the management of the material in large masses has hitherto been understood, it has in many instances cost quite as much as brick; the comparative slowness with which the water is eliminated renders the wall liable in our northern climate to be suddenly disintegrated by frost. Because concrete has answered well in foundations, the conclusion has been too hastily arrived at, that it would therefore be equally suitable for houses. The duty it has to perform in the former case is to transmit the superincumbent pressure to the ground; and the only resistance that the material is called upon to display, is that against crushing. To secure rigidity and stability in unsupported walls, requires peculiar care and knowledge in selecting and compounding the materials. All artificial monolithic masses labor theoretically under the common disadvantage of their soundness being in the inverse ratio of their size. Not only is this true for artificial, but also for natural substances. These facts have led to the disuse of concrete for binding rubble into the form of walls, and the adoption of building blocks which are made of such size that one man may readily handle them, and which are simply bricks of concrete. This system also allows of the introduction of "bond," which does not, strictly speaking, exist in the rival principles, and there is, therefore, the absolute necessity for introducing binders, and joists, as soon as possible, in their case. The composition of these blocks differs from that of the ruder concrete in the addition of hydraulic or Roman cement, by which their hardening is much facilitated. The blocks are formed in wooden molds, and require in their manufacture only a moderate degree of skill, the material being made by combining, in a wet condition, caustic lime, cement, and sharp sand in about the proportions of 1 bushel of lime, 6 of sand, and 4 quarts of cement. The blocks require considerable time to harden solidly throughout, and should be kept under shelter. Some manufacturers facilitate the manufacture, and also the hardening, by mixing the ingredients by machinery, by means of which steam and hot water are injected into the plastic mass while mixing.

Recent experiments by a German investigator seem to show that the costly hydraulic cement may be dispensed with, when the blocks are not placed under water, by employing a kind of mortar made of slaked lime and finely sifted sand. Caustic lime, equal to $\frac{1}{4}$ of the sand used, is mixed with the mortar when required for use; the heat resulting from its addition induces the formation of silicates, which quickly harden the mortar.

It has been suggested that, inasmuch as the hydraulic cement heretofore so largely employed, owes its efficacy to the silicate of alumina contained therein, an artificial cement may be made for the purpose, by properly mixing lime with 20 per cent. of dry clay.

A modification of the "block" system, is the slab system. The difficulties attendant upon it appear to be, principally, the impossibility of ensuring the perpendicularity of the upright portions of the house, the squareness of the angles, or the sharpness of the arrises. The idea of attempting to raise walls 20 feet and 30 feet in height, by means of small angle iron uprights and slabs of concrete, from 3 inches to 4 inches in thickness, is a simple absurdity. The house consists of nothing but panelling, and one is puzzled to decide whether one is really inside or outside, as the walls appear to have literally no consistency or solidity.

For facilitating the construction of solid concrete buildings, a Mr. Drake has taken a patent in England, for the use of flanged iron plates, supported by iron uprights secured against the face of the wall, such plates to be shifted upwards step by step upon the uprights, and locked to them in the several positions by pins. He also claims angle plates to form the angles of walls ; also the use, to connect the front and back plates and uprights, of metal straps with pinholes in them at various distances, so that the length may be adjusted to the thickness required.

Several extensive structures are now erecting in England by the solid method, among them a large warehouse in London 70 feet by 60 feet by 50 feet, which will no doubt prove a success, because the work is carried on under the superintendence of those who thoroughly understand the subject, both theoretically and practically. The Duke of Northumberland is constructing a solid cottage of Portland cement concrete. The foundation set on sand, is 6 inches thick and 18 inches wide ; the walls are 9 inches in thickness and 2 stories in height. The roofs are all flat, and are constructed entirely of concrete and old wire rope. The ceilings are divided into panels by ribs at right angles, and require no plastering. A wall on the upper floor is supported on a concrete beam, 13 feet span ; a large cistern is formed under the roof, its sides being the walls of a room ; this will severely test the impermeability of the material. No wood is used except for doors, and no iron, except the old wire-rope.

GOLD AND SILVER.—A recent estimate makes the total quantity of gold, in the form of coin, jewellery, vessels, utensils, in fact in all shapes, in the hands of man, equal in value to £1,200,000,000 sterling. This would be 300,000,000 ounces, or 30,000,000 cubic inches. If converted into a single block, its dimensions would not be less than 26 feet square, and its weight 10,500 tons. In the shape of sovereigns placed in a single line on the ground, each coin being in contact with its neighbor, £1,200,000,000 sterling would form a track 4,300 miles in length.

The value of the silver in use is set down at £1,000,000,000 sterling in value. This, in round numbers, would be 4,000,000,000 ounces, or 400,000 cubic feet, measuring 100 feet square by 30 feet in height. In the shape of shillings, placed in contact and in line, the globe itself would be more than twice encircled by this amount of silver.—*Mechanics' Magazine.*

WATER-SUPPLY FOR CITIES.

IMPORTANCE OF PURE WATER—SEWAGE—ARTESIAN WELLS—PARTICULARS OF EXISTING WORKS—PUMPING MACHINERY.

From the excellent report of Chas. Hermany, Esq., Chief Engineer of the Memphis Water Works, we compile the following considerations and facts on this subject, and they are especially interesting and important to the inhabitants of towns not yet well supplied with pure water:—

One of the first and leading considerations in the selection of abiding places for man, whether it be the cave of the savage, the hut of the barbarian, the cottage of the peasant, the camp of the soldier, the residence of the man of wealth, or the site of a large city, is the supply of an ample quantity of pure and wholesome water. Nature, however liberal, does not always make ample provision for supplying the wants of man, inasmuch as springs, brooks, and rivers are not sufficiently numerous to furnish water of suitable quality *everywhere* where man chooses abiding places; hence his ingenuity or constructive ability is called into action, and wells are formed by excavations in the earth from which water is obtained for limited numbers in localities more or less remote from natural water-courses.

Quality of Water.—In cities where large populations dwell upon comparatively small areas of land, this mode of obtaining water fails, both as regards quantity and quality. Upon the sites of many towns and cities, wells wholly fail to furnish water of suitable quality; hence rain-water cisterns, constructed under ground, and located in streets, courts, alleys, yards, basements, etc., into which that portion of rain falling upon the roofs of the houses, and not evaporated or absorbed, is conducted and stored for use. These modes of water-supply are very expensive, considering the limited quantity and deteriorated quality furnished. The principal cities of the United States, in times of sickness or epidemics, had the *prevailing diseases* to much greater extent, and much more aggravated cases, by virtue of the fact that limited quantities of indifferent or bad water aided climatic causes in developing and prolonging epidemics. In the city of New York, as early as 1798, while the necessity of a supply of pure water was already severely felt, Dr. Brown, in a report upon the subject in the same year, "exhibits circumstantially the consumption of water as of a very small quantity (on account of the difficulty of procuring it), and subordinate quality; he considers this as the cause of a variety of diseases and contagious disorders, especially the yellow fever, which had recently made great ravages there. He also considers the state of health of a populous city as depending *more upon the purity of its water* than the quality of all the rest of its provisions together."

In the city of Philadelphia, as early as 1793 or 1794, Benjamin Franklin was, it is believed, the first who publicly called the attention of the citizens to the subject of watering the city from some other source than the wells then universally used; urging that the afflictions from the ravages of contagious diseases rendered it necessary that a more copious supply of water should be procured, to insure the health, comfort, and preservation of the citizens. This was just after the city had been visited by the yellow fever. And in Franklin's will, dated June 23, 1789, is the following clause: "and having considered that the covering of the ground plot of the city with buildings and pavements, which carry off most of the rain, and prevent it soaking into the earth, and renewing and purifying the springs whence the waters of the wells must gradually grow worse, and in time be unfit for use, as I find has happened in all old cities, I recommend that at the end of the first 100 years, if not done before, the corporation of the city employ a part of the £100,000 in bringing by pipes the water of the Wissahiccon Creek into the town, so as to supply the inhabitants."

To sum up all the advantages from a properly devised public water-supply, would require a lengthy dissertation upon the subject; we will therefore briefly enumerate some of the principal ones only.

1. It furnishes a better quality of water than is possible from wells and rain-water cisterns, and at a much cheaper rate for the same quantity than can be obtained by private or individual means of supply.

2d. It encourages a liberal use of wholesome water by all classes, and thereby induces habits of cleanliness and comfort, diminishes sickness, and in times of epidemics it has proved by the experience of other cities to be the greatest protection to densely populated districts.

3. By the constant command, at all hours of the day and night, of an unlimited quantity, for protection against the ravages of fire, it reduces the risks for insurance companies, and with that the rates of insurance, and in this way, perhaps more than in any other, is a well-regulated public water-supply productive of pecuniary advantages, which annually amount to a very liberal percentage on the capital invested.

4. It invites settlement, and encourages the investment of capital in manufacturing enterprises, which, by fostering productive industry, tend to build up the city in the elements constituting permanent wealth and independence.

As to the quality of the sources of supply, the report says: All the natural water-courses in every country become more and more impure with the increase of population, and less suitable for distribution in densely populated cities; and the best practice of hydraulic engineering, in its application to public water-supplies, is to collect and store the water as near as practicable to the gathering grounds, upon which it falls in the shape of snow and rain, and thence convey it artificially to the place of distribution. The truthfulness of this is illustrated by the following-named examples of water-supplies to towns and cities in the United States, where the water is collected and stored in reservoirs near the limits of the drainage areas supplying them, viz.: the Boston and Charlestown water-supplies in Massachusetts; the Albany, Croton, and Brooklyn water-supplies in New York; and the Hartford, Ct., and Baltimore, Md., water-supplies. The last two of these have changed within the last few years from taking their daily supplies from natural water-courses to storage reservoirs approaching the limits of the drainage areas supplying them with water. The Loch Katrine scheme, supplying the city of Glasgow; the Rivington Pike scheme, supplying Liverpool; the Birmingham water-supply; and the contemplated change in the mode of supplying the city of London with water, are cases in point, and demonstrate the justice and propriety of this view of the subject.

SEWAGE.—As the congregation of large numbers of human beings upon comparatively small areas has been shown to defile the spring and well water, as also the rain-water, by causing it to absorb in its fall the noxious gases which constantly arise from populous cities, as well as from the washings of the roofs, consisting of an almost endless catalogue of articles prejudicial to health, thereby compelling a supply being obtained from a source beyond the reach of city defilement, it must not be concluded that with the procurement of pure water the evil is remedied; it is only one of the effects which is obviated, for the evil itself continues to grow with the increase of population, until the earth or subsoil of the city is so thoroughly permeated with human excreta as to render its removal an absolute necessity; to accomplish which end, capital and industry, under the direction of the civil engineer, have constructed systems of sewers, through which, with the water from public water-supplies and rains as vehicles, the refuse, etc., from dense populations is carried to running streams and rivers, to be diluted to an extent which makes it harmless. Hence a system of thorough drainage, through the medium of sewers, is next in importance to a public water-supply for a city as a means of preserving the health of its inhabitants. This is a subject upon the investigation, development, and perfection of which the ablest statesmen, scientists, and engineers of great Britain and the continent of Europe have been engaged for years; and in the United States, also, much attention has been given to the subject, although the literature or written experience in relation to it is quite meagre. In a late publication* upon this subject the author truthfully remarks: "The general standard of public morals always corresponds with the state of public health, the latter depending again upon abundance of food combined with a pure atmosphere and an unlimited supply of undefiled water. * * *

In nothing is the superior wisdom of the present Emperor of the French so manifest as in the undivided attention he,

* Kropp's London Sewerage.

like the founder of his dynasty, pays to the sanitary, agricultural, industrial, and commercial interests of his people, which thus manifestly proves that true statesmanship finds its best allies in agriculture and public health."

The tables 1 and 2 give respectively, the quantity of water consumed, and the cost and other mechanical features of water-works in various cities. Table 3 gives the particulars of the principal artesian wells. Table 5 gives the duty of several of the best engines in the country, and is taken from the report of Jas. P. Kirkwood, C. E., on the Brooklyn water-works.

TABLE 1.

YEAR.	CITIES.	Each Inhabitant, per day.	Each Consumer, per day.
		Gallons.	Gallons.
1867.............	Charlestown, Massachusetts..............	41.83	54.33
1867............	Brooklyn, New York......................	.....	*47.10
1866.............	Cleveland, Ohio..........................	22.35	24.26
1867.............	Detroit, Michigan.........................	48.46	54.47
	Chicago, Illinois.........................	50.00	.....
	Cincinnati, Ohio	.....	.....
1864.............	St. Louis, Missouri.......................	.....	*54.01
1866.............	Louisville, Kentucky......................	16.81	73.96
1864.............	New York.................................	62.00	.....

TABLE 2.

CITY.	YEAR.	POWER.	Different Level between Source and Delivery	What Portion of Pumping Capacity Daily Required. Maximum.	Average.	Cost per Million gallons elevated 100 feet.	Order of Economy.
Cambridge, Massachusetts.......	1866	Steam	72½	.....	.....	$18 02	10
Charlestown, Massachusetts......	1865	Steam........	135	0.228	0.177	14 97	6
Hartford, Connecticut...........	1866	Steam........	120	.....	.....	16 34	8
Brookly, New York..............	1866	Steam........	161	0.440	0.380	12 84	4
Jersey City, New Jersey.........	1866	....	159	0.285	0.269	9 63	1
Fairmount, Philadelphia, Penn...	1866	Water Power..	...	1.000	0.605	2 00	0
Schuylkill, Philadelphia, Penn....	1866	Steam........	115	0.414	0.290	13 00	5
Delaware, Philadelphia, Penn....	1866	Steam........	112	1.000	0.806	22 00	13
24th Ward, Philadelphia, Penn...	1866	Steam........	...	1.000	0.615	9 91	2
Germantown, Philadelphia, Penn.	1866	Steam........	...	0.272	0.215	23 10	14
Cleveland, Ohio.................	1865	Steam........	158	0.200	0.154	17 55	9
Cincinnati, Ohio................	1866	Steam........	165	0.712	0.546	18 09	11
Louisville, Kentucky............	1866	Steam........	144	0.200	0.123	16 14	7
Chicago, Illinois...............	1865	....	125	0.540	0.354	12 20	3
Detroit Michigan...............	1867	....	75	0.410	0.360	18 20	12

THE ARTESIAN WELL, sending forth a constant stream of pure water, is a beautiful and interesting sight; and in the popular mind it is invested with a great degree of novelty. What is an artesian well? Historically, it is so called from a mode practised in Artois, a province in France, by boring for water. Technically, an artesian well is a mode for obtaining a spontaneous flow of water, at or above the surface of the earth, through the medium of a tubed perforation of the earth's crust, extending in depth until a body of water is reached, from which, by hydrostatic pressure, a portion is delivered through the tube at or above the surface of the earth. The most plausible theory, explanatory of the flow of water

* Approximate.

from artesian wells, is their similarity to natural springs, there being in both contracted apertures from the surface of the earth to the subterranean reservoirs full of water, and compressed by columns of this liquid. Through these apertures (natural fissures in the earth in the case of springs, and artificial borings in the case of artesian wells) the water escapes, seeking its level. The history of artesian wells, so far as they have been resorted to as a means of supplying towns and cities with water, is not at all encouraging, whatever may be their merits as means of obtaining limited quantities of water for private or special uses.

TABLE 3.

Artesian Wells.

NAME.	LOCATION.	Depth of Well.	Diameter of Bore at Bottom of Well	Quality of Water.	Temperature of Water.	Length of Time in Boring Well.	Elevation of Discharge + or − Surface of Ground.	Discharge per 24 hours, in U. S. gallons.	Total Cost of Well.	First Cost in measures of 1,000,000 gallons in 24 hours.
FOREIGN:		Feet.	In.		°Far.	Yrs.	Feet.			
Grenelle	Paris....... ..	1,806	6	Fresh..	$82\frac{1}{2}$	7	..	175,104	$70,180 00	$401,028 00
Passy	Paris.........	....	..	Fresh..	..	..	+66	2,188.800	......	....
Kissengen....	Bavaria	1,878	..	Mineral	66	..	+58	1,077,120	32,263 00	30,050 00
Aire	Artois, France	....	..	Fresh..	..	..	+11	360,000	......	....
UNITED STATES:										
Charleston...	South Carolina	1,250	3	Salt ...	87	..	+10	30,000	20,000 00	666,666 66
Belchers	St. Louis.....	2.199	$3\frac{1}{2}$	Salt ...	73	5	−30	108,000	20.000 00	185,185 18
Du Pont's...	Louisville, Ky.	2,086	3	Mineral	..	$1\frac{1}{2}$	+170	330,000	10,000 00	30,303 03

TABLE 4.

Summary of the Estimated Costs of the Three Different Plans proposed for Memphis.

BRANCHES OF WORK.	Wolf River Plan.	Mississippi River Plan.	Hatchie Lake Plan.
Wolf River Aqueduct.....................	$933,332 51	....	....
Inlet and river work....................	....	$342,231 78	$191,862 66
Buildings at pumping station............	67,872 60	230,135 20	230,135 20
Pumping machinery.......................	100,000 00	225,000 00	260,000 00
Settling reservoirs.....................	373,327 90	280,533 00	310,016 41
Pipe system.............................	505,886 60	483,339 60	903,089 60
Distributing reservoir..................	349,009 10	349,009 10	349,009 10
Totals..........................	$2,329,428 71	$1,910,248 68	$2,244,112 97

TABLE 5.

Duty of several of the principal Pumping Engines in the United States.

Date of Experiment.	Hours.	ENGINE.	Pounds Lifted One Foot High.
January, 1860....	26	Brooklyn engine, Cornish..........................	601,407
January, 1857....	12	Belleville engine, Cornish.........................	628.233
January, 1857....	$8\frac{1}{2}$	Hartford, Crank....................................	587,793
July, 1857....	$17\frac{3}{4}$	Hartford, second trial, first experiment...............	614.426
July, 1857....	12	" " " second experiment............	646.994
April, 1857....	9	Cambridge, "Duplex"...............................	669,411
June, 1857....	$14\frac{3}{4}$	" " second trial..................	675,746
June, 1856....	48	Spring Garden, Philadelphia, Cornish................	589,053

The following extracts are from a report by V. Dumas, member of the French Academy of Sciences, to the Minister of Public Works, on the subject of the exclusive water-supply of Paris by artesian wells:—

"The commission is unanimous (against the scheme). Among its members there are none who are unaware of the importance of artesian water drawn from the green sand for the use of Paris. But among those who base upon it the greatest expectations, there are none who are of opinion that it would be advisable to exclude the employment of other resources that nature or art has placed at the disposal of the Parisian people. * *

"1. The water-bearing stratum of green sand is not the exclusive property of the city of Paris. It can be operated upon at any distance or level by the proprietors of the soil. The works constructed by companies, associations, and individuals, however great or indisputable may be the capabilities of this source, could absorb them and render them of very doubtful application to the municipal wants.

"2. The phenomena and natural accidents, such as earthquakes, that exercise little influence upon canals through which flows surface water, could, on the contrary, produce on channels for the passage of water at great depths a derangement of their course.

"Though such events may be rare, it is sufficient to know that once in twenty years their effect on the well of Grenelle has been observed, not to be willing to expose the city of Paris to receive suddenly and for entire months turbid water in all its reservoirs, or to submit to a diminution of one-half the product of its flowing wells, which, though it were but temporary, would not be the less serious.

"3. The art of boring is not yet advanced enough by experience in tubing very deep wells of large diameter, especially in what concerns the green sand basin ; tubes in iron do not last ; copper tubes even, lined with tin, might fill the people with anxiety in times of epidemic; wooden tubes are uncertain; and wells not provided with tubes have not been thoroughly experimented with.

"4. The water of the artesian source, which is of great purity, and which, so far as mineral substances are concerned, is better suited than all others for industrial and public use, is very slightly aerated and tepid. It would be necessary, therefore, to cool and aerate it, to render it useful for domestic purposes ; and for this reason it would be regretted that it is not a little richer in carbonic acid and carbonate of lime.

In conclusion, when we talk of supplying 2,000,000 inhabitants, it is prudent to assure ourselves of the simultaneous use of bodies of water taken from various sources, in order to be always ready to quiet the complaints of the people. Water, as we have said, ought never to be suspected ; and, in case of the least doubt, the administration must be able to replace one water, though suspected without cause, by another which may possess the confidence of the consumers.

The Memphis Works.—The plans proposed for the supply of Memphis are :—

1. A supply from Wolf river, taken at the most available point above the town of Raleigh.

2. A supply from the Mississippi river, drawn at the first suitable point above the city.

3. A supply from the Mississippi river, taken in the vicinity of Hatchie Lake.

The Pumping Machinery recommended in the report for the Wolf River Works, is the Worthington Duplex Pumping Engine. The report says:—

This machine is strictly a steam pump, consisting of two steam cylinders and two water cylinders laid horizontally in pairs, the piston rod of each steam cylinder extending to its water cylinder and working a water-displacement plunger; the steam and water cylinders being separated a sufficient distance to permit the requisite mechanical devices to be attached to each connecting rod between the steam piston and the water plunger, for working the steam valves and air-pumps; the connecting rod of the right-hand engine working the steam valves and air-pump of the left-hand engine, and *vice versa.*

The machine is self-contained, and does not require expensive masonry foundations; it works horizontally; has the smallest mass of inert matter in the moving parts, being just sufficient for the safe transmission of the power; and thus, in conjunction with its moderate velocity, reduces its liability to accidents to a minimum. The valves are multiform vulcanized rubber disks, strengthened by perforated cast-iron disks, the rubber seating upon grated composition-metal valve seats; the receiving and delivery valves are disposed in sets vertically one above the other, and rise and fall vertically.

In the economical use of fuel this engine compares favorably with the best pumping-engines in the country; and in its daily performance it will give moderately good results, with perhaps less attention from skilful enginemen than any other kind of pumping-engine now in use, being nearly automatic in its operation. It has been in use for a number of years, and there are at present in successful operation as follows, to wit: 1 pair at Harrisburg, Pennsylvania; 1 pair at Greenwood Cemetery, Long Island; 2 pairs at Cambridge, Massachusetts; 2 pairs at Charlestown, Massachusetts; 1 pair now being erected at Salem, Massachusetts; and 1 pair at Newark, New Jersey; the last 4 named being each capable of elevating 5,000,000 gallons water per 24 hours.

Wherever this pumping-engine has been in use, it has given entire satisfaction, and, with the exception of the Cornish pumping-engine, it has been duplicated a greater number of times than any other engine for water-work purposes, despite its recent origin.

PREVENTION OF SCALE IN BOILERS.

Translated from Dingler's Polytechnic Journal, by John B. Pearse.

In a late meeting of the Society of German Engineers for the Westphalian District, this subject was proposed for discussion. The remarks were opened by Dr. List, who divided all the means for its prevention into two classes : 1st, those consisting in the addition of various substances to the feed water; 2d, those consisting in the use of special apparatus. The former class of means includes among many others the use of starch or substances containing it, which shall cause the precipitation of the solid matter as powder or mud and not as scale. The results obtained by the use of starch were unfavorable according to the experience of a member. Dr. List mentioned the use of a soft greasy variety of clay, more or less mixed with bituminous matter (Halloysite). Mining Inspector Schrader stated that such clay had been advantageously used at several coal mines with which he was acquainted. Dr. List supposed that the particles of solid matter on being precipitated were taken up by or clung to the clay, instead of adhering to the bottom and sides of the boiler.

Dr. List also mentioned the use of various substances containing tannin. Their utility might be explained both on mechanical and chemical grounds. He had himself obtained favorable results from their use in water containing lime. In sugar factories the addition of crude molasses to the water had had a good effect.

As far as the chemical action is concerned, the utility of such additions depends on the composition of the water. If the latter contains gypsum or sulphate of lime, scale is formed, because the relative quantity of gypsum increases as the water is evaporated, and because the solubility of the same decreases with the heat of the water. If the water contains double or bicarbonate of lime, this compound is decomposed by the heat, and the simple carbonate is precipitated as scale.

The *gradual* separation of these substances causes the formation of scale. Chemical means may prevent such separation, or may hasten it so much that mud is formed instead of scale.

Sal-ammoniac is recommended for preventing the precipitation of lime by forming the readily soluble chloride of calcium. This means is frequently used, particularly in Holland, for locomotives. The most natural means, however, for water containing bicarbonate of lime, would be to hasten the precipitation by the use of a solution of slaked lime in water, or "lime water." This would separate all the bicarbonate of lime as an insoluble mud. Chloride of barium would be the best addition to waters containing sulphate of lime, or those from many coal mines, and would act in a similar way.

Carbonate of soda is recommended from actual experience as an effectual means of preventing scale from water containing either carbonate or sulphate of lime.

M. Helmholy remarked that he had

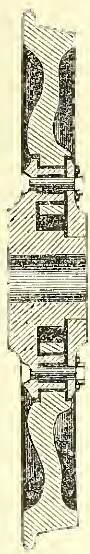
observed incrustations in Giffard's Injector, where the motion of the water was quite rapid. M. Weistman had also observed scale at point, where the velocity of the water was considerable, but mentioned the absence of scale in the boilers of steam fire engines. M. Kamp had also observed the deposition of scale in feed water pipes, although the deposition in the boiler was inconsiderable.

The translator has observed a case where it was attempted to blow charcoal through tubes by means of air, possessing considerable velocity. It was found that although the wind would take along with it some considerable quantity of charcoal, it would nevertheless deposit a good deal again, before reaching its destination, particularly at places where there were angles, or the pipes expanded slightly. The deposition of scale in the injector and feed water tubes might be thus explained without weakening the reasoning of Dr. List, which seems quite correct and conformable to experience.

ELASTIC RAILWAY WHEELS.

Over 10 years ago, that veteran Locomotive Superintendent, Mr. George S. Griggs of Boston, commenced using blocks of wood an inch thick, forming an almost continuous tyre, between the iron tyre and the cast-iron driving wheel rim of his locomotives. The results have been well defined and entirely good and economical, and they have certainly not been arrived at without due trial. The wear of tyres and the breakage of wheels and connected parts has been decidedly lessened by the interposition of this elastic medium, slight as is its yielding; and if of tyres, then of rails and permanent way, for although there may be 30 or 40 times as many truck wheels as drivers in a train, the drivers are 5-ton hammers, while the truck wheels are only little 2-ton smithshop hammers, that would not be employed by knowing smiths if the lamination of rails was the thing to be aimed at. Every body concerned has known all about Mr. Griggs' wheel for years, but it is only just now getting into general use.

Mr. W. Bridges Adams, of London, another veteran engineer, long since devised the "horse-foot" tyre—a steel spring between the tyre and the rim of the wheel, and although it gave good results, it has not yet been largely adopted. The wooden car wheel, with an iron hub and steel tyre, long used abroad, is just beginning to be appreciated here. It is in use on the drawing-room cars of the Hudson River Railway.



Another elastic wheel, for cars and other vehicles, a section of which is shown in the engraving, has been devised by Mr. John Raddin, of Lynn, Mass. The hub, and the web and tread are separate castings, between which there is interposed a ring of india-rubber. The holes in the web to receive the projections on the hub, are larger than the projections, so as to give a slight play—say one-eighth of an inch maximum. The rubber being compressed tightly in the annular space, cannot be squeezed out, but can only change its figure when the load comes upon it. The entire *jar* of the wheels is thus absorbed by the rubber before it reaches the hub and the axle. That both the running gear and the permanent way will be made safer and more durable by this elastic relief, is perfectly well assured by similar results in railway and other engineering practice. The economy of having the wheel in two parts, so that the tread may be renewed without forcing the hub from the axle, is obvious. The theoretical advantages of an elastic wheel will not be questioned by intelligent practitioners. Are there any practical defects or weaknesses in this method of application? The management of the Eastern Railroad say that after running 8 of these wheels for 9 months under a 22-ton iron car, an examination showed the rubber uninjured and the nuts all tight, though the bolts were not headed. The same wheels since placed under a passenger car, have run, in all, 40,000 miles with decidedly less wear on the tread than solid wheels. The Engineer of the Boston Fire Department gives an equally good account of similarly cushioned fire-engine wheels.

The use of elastic media between parts subjected to jarring, is now so well understood by railway managers, that we expect to see other and better applications.

Here is a large field for experiment and invention. Although the uniform elasticity of permanent way should be much better provided for than it is, the cost of a pair of well-appointed cushions upon each of a hundred million railway sleepers, looks rather formidable. The proper cushioning of a thousandth part of that number of the heaviest-loaded wheels of engines and trains, is more likely to be accomplished, and would do more good in proportion to the cost.

BRITISH RIFLED ARTILLERY.

Rifled guns had been experimented upon in England for about half a century before they were put to any practical test, but when the Russian war was imminent, it became necessary to adopt some form of rifled artillery, in order to oppose the rifled small-arms which began to be generally adopted. Metallurgy and mechanics had been improved in consequence of the stimulus given to these sciences by the great demand for efforts of civil engineering, and without these improvements the manufacture of rifled ordnance would have been impossible. When the war with Russia broke out, some 8-inch and 68-pounder iron guns were bored on Lancaster's system, and sent to the Crimea and to the Baltic, but they were of small avail, as the straight-sided projectile often jammed in their spiral bores.

It was in the Italian campaign of 1859 that rifled artillery was first used with any effect. The Emperor of the French, with his muzzle-loading bronze rifled field guns, did great execution, especially at Solferino, and scattered terror in the Austrian ranks more by the range than the accuracy of their fire. This success induced all European Powers to turn their attention to rifled artillery. Austria adopted the French system, while Russia and Prussia became converts to a breech-loading action invented by Mr. Krupp. England turned her attention to a breech-loading system invented by Mr. Armstrong, of Elswick. His guns were tested by the rough usage of war in China in 1860, and acquitted themselves admirably. It was known then that the Armstrong guns were excellent, and exceeded in range and accuracy those of any Continental Power. It was vainly thought that this system would have been permanently adopted into the service, at least for field artillery. The same system of ordnance did good service in New Zealand in 1864, but, though no enemies could stand against it in the field, it had potent antagonists at home.

In 1863, under the pressure of polemical writings, the Secretary of State for War appointed a committee to examine and report upon the different descriptions of guns and ammunition brought forward by Sir W. Armstrong and Mr. Whitworth. This committee sat for two years, and conducted a series of experiments, which cost £35,000 in stores alone. The total expenses cannot have amounted to much less than £60,000, and the result was that the experiments were very creditable to both inventors. The contest was very close; and surely no country but England, when it had a gun better than that of any Continental nation, would have spent £60,000 in investigating the infinitesimal differences between it and the offspring of some rival inventor. Still we did so; and the committee which was called on to decide this question thought that muzzle-loading guns, which had been already six years in the French service, were superior to breech-loaders for the service of field artillery. This opinion necessitated another committee to decide on the rival merits of muzzle-loading or breech-loading field artillery. In 1866 another committee assembled to discuss this question, and decided that muzzle-loaders were better adapted for field service than breech-loaders. The consequence was, that a muzzle-loading gun slightly different from the French gun was considered the proper gun for our field artillery, on account of its simplicity. We had thus spent at least 7 years and lost vast sums of money in determining theoretically that a gun which had been adopted at the outset by the French was better than our own, which had been proved to be most excellent on two separate occasions in active service. Yet when we had obtained this decision we could not act upon it, as we dare not incur the expense of arming all our field batteries afresh with muzzle-loading guns. This is the plain result to which we have attained in field artillery; of heavy guns we propose to speak at a future time. The money which has been squandered in experiments cannot be recovered; it is hopelessly lost; and, of course, in a short time, in consequence of the decision of the last committees, unless, indeed, they are subverted by those of some future bodies, our breech-loading field artillery will be supplanted by muzzle-loaders.

Yet is there much reason that this expense should be incurred? It would, perhaps, have been better to have adopted a muzzle-loading gun in the first instance; but, now that we have a breech-loader, is it worth our while to incur all the expense and inconvenience of changing our armaments in order to gratify the whims of theorists or the fancies of mathematicians? The breech-loading gun has been found to do good service in China and New Zealand, and is undoubtedly far above the average as a gun. In the late German war the breech-loading gun triumphed over the muzzle-loader, and the victorious Prussians have adopted it it universally into their service. Impartial and experienced judges, who saw it in action, have told us that the breech-loading gun of the British artillery proved itself superior in China to the Prussian gun in Bohemia. It is, no doubt, superior to the Austrian muzzle-loader, which is very similar to the French gun. Why should we, then, incur a great deal of expenditure to change our armament, when we can already more than hold our own against that of any other nation? Metaphysicians and fanciful artillerists may aim at perfection, but we cannot afford to adopt every momentary invention which professes a very small advantage over the system already adopted into the service. We might, possibly, if we were to reconstitute our whole system, institute muzzle-loaders, and so reap all the fruits of our experience; but now that we have a gun in the service which is considerably better than any possible antagonist, we must deprecate the expense necessary to change for any fanciful advantage. We must remember that, ere the muzzle-loader can be made our armament, some new invention which will nullify it may be brought forward, and, happy in the goodness of our bad bargain, we may be quite content to let well alone.—*Army and Navy Gazette.*

LOCOMOTIVES OF THE NORTH LONDON RAILWAY.—The standard engines of this line are fully illustrated in the "Engineer," Dec. 11 and 25. They have 2 pairs of connected drivers 5 feet 3 inches diameter, and 8 feet apart centres. The truck has 4 wheels, 2 feet 8 inches diameter and 5 feet 8 inches apart. The centre of truck is 9 feet 10 inches from the centre of forward driving shaft. The boiler shell is 4 feet 1 inch inside diameter by 10 feet $2\frac{1}{2}$ inches long, and contains 122 tubes 2 inches diameter. The fire-box is 4 feet $5\frac{1}{2}$ inches long by 3 feet $7\frac{1}{4}$ inches wide by 5 feet 4 inches high inside. The cylinders, outside, and inclined 1 in 12, are 17 inches diameter by 2 feet stroke. The steam-chests are inside, and the link-motion valve connection is direct. The tanks (1,000 gals.) are at the sides of the foot-plate and in rear of the boiler. The working steam pressure is 160 pounds. The peculiar and strong cylinder fastenings, and the great extent of the rubbing surfaces, are especially referred to. The weight of the engines is as follows;

	Light. tons	Light. cwt.	Full. tons	Full. cwt.	Full. qr.
Bogie, four wheels	15	14	14	14	2
Driving wheels	11	11	14	5	0
Trailing wheels	11	7	14	12	2
Total	38	12	43	12	0

Five of these engines are now completed or in progress; they easily take trains consisting of 30 wagons, each weighing over 5 tons, and containing 10 tons of coal, and 2 heavy brake vans, or about 460 tons in all, up inclines of 1 in 100 in all sorts of weather. Equilibrium slide valves are used on these and all the new engines of this line with great success. The valve has the equivalent of 2 pistons in the back. Two circular flanges project from the back, nearly up to the steam-chest cover. Around these are packing rings which are forced up against the steam-chest cover, with a small pressure due to their area, thus making a tight joint. The area enclosed by the ring is open to the exhaust passage of the valve.

ALUMINIUM BRONZE is used in France for saws and other mechanism requiring great strength and hardness, in place of steel. It has been proposed to cover the steps of the column in the Place Vendome with the same material.

ORDNANCE AND NAVAL NOTES.

Whitworth Gun—Late Experiments. The longest range of cannon shot ever attained, was made by the Whitworth ordnance at Shoeburyness in November last, viz.: 11,300 yards, or nearly 6½ miles. The longest range previously recorded, was obtained in 1861 by Lynall Thomas' 175 lb. shot with a 25 lb. charge, from a 7 in. steel gun at 37½° elevation, viz.: 10,075 yards.

The Whitworth gun referred to, has 9,025 in. (major) and 8.25 in. (minor) hexagonal bore, 140.06 in. long with 1 turn in 117 in. The shells used were cast iron, 31.6 in. long, 8.96 in. major, and 8.18 in. minor diameter, with capacity for 18 lb. bursting charge. The shot were cast iron, 24.5 in. long. The wads were hexagonal; weighing 1 lb. each and made of paper maché. Large grained rifle powder was used. The result of the firing was as follows:

No. of Shot.	Weight of Projectile, lbs.	Weight of Charge, lbs.	Elevation.	Range, yards.	Time of Flight.	Deflection, yards.
1	310	50	10°	4,868	13.5 sec.	1 L
2	250	50	10°	5,196	14.2 sec.	7 R
3	310	50	10°	4,021	12.1 sec.	6.2 R
4	250	50	33°	11,300		
5	250	50	33°	11,234		
6	310	50	33°	11,075		
7	310	50	33.5°	11,127		

New British Gun.—An order has been issued from the War-office announcing the introduction into the service of a new description of wrought iron muzzle-loading 10 in. 18-ton gun, of which the following is the official technical description:—Length of gun, 14 ft. 2 in.; mean weight of gun. 18 tons 24 lb.; mean preponderance, 8 cwt. 1 qr. 24 lb.; length of bore, 145.5 in.; length of rifling, 118 in.; calibre, 10 in. The "A" tube is to be made of tough steel. This new description of ordnance is of the general type represented by the 7, 8, and 9 in. guns. They are rifled upon the Woolwich system with seven grooves, having a twist increasing from one turn in 100 calibres at the breech to one turn in 40 calibres at the muzzle.

The vent enters the bore at 11 in. from the end, and upon the right-hand side, at an angle of 45 deg. to the vertical axis on the transverse section, and directed to the axis of the gun. The vent consists of a steel bush, lined with copper, screwed in from the exterior against a platinum tip screwed up from the interior. This tip has a flange, or button-shaped head, projecting into the bore, as a means of preventing the gas escaping into the joint. A projecting head is left upon the bush to enable it to be removed when required by a spanner. The bottom of the vent is enlarged to a diameter of .32 in., tapering up to .222 in. (the diameter of the vent channel) in a length of one inch. The guns are sighted in the ordinary manner at a deflectional angle of 1 deg. 10 min., but this angle is only to be regarded as provisional. They are fitted with "plates, metal, elevating," and "pivots." The cascable faces are graduated for the Engineer of the road tangent scale use.

Use of Railways in War.—The movements by railroad of the Ninth corps under General Burnside, from Central Kentucky to Vicksburg; the transfer of the Twelfth and Thirteenth corps, under Hooker, from Washington to Chattanooga; of the Twenty-third corps from Eastport, on the Tennessee, to Washington, are remarkable instances of the usefulness of this new military arm. The last-named marvellous feat, Mr. Stanton declared to be "without parallel in military history." The distance travelled was 1,400 miles, the troops moved were 20,000 strong, besides 1,000 animals and a full artillery train. It was accomplished in mid-winter, with rivers and roads blocked by ice, in an average time of 11 days for each subdivision.

The campaign of 1866 in Germany demonstrated the importance of the part which railways are called on to play in modern strategy. The Federal Council of Northern Germany has had under consideration a proposition for the drawing up of a complete table of the resources and military advantages of the lines included in the Confederation. With this view a statement is to be compiled every two years, commencing with 1870, in accordance with an official formula, showing the capabilities, in a military point of view, of the existing railways and the branches to be constructed. An interesting work has been written on the subject in German. The Italians are busy organizing a system for turning their lines to the best use, and here engine-drivers and stokers are attached to every regiment.

Use of Breech-loaders Abroad.—In the North German army the infantry of the line and the guard are all armed with needle-guns, of which there is also a sufficient supply for the reserve and for the garrisons. The arming of the whole of the landwehr with converted needle-guns was also decided upon last June. Of the South German troops, those of Hesse, Baden, and Wurtemburg are all armed with the needle-gun, while Bavaria only began a few months ago to supply the Werner gun to her army. Austria had armed 300,000 men with the converted Wanzl last July. The whole of the French army may be regarded as being supplied with the Chassepot since last spring. In Belgium the Albini gun was to be in the hands of every soldier of the line by the 1st of October. In Italy 32 battalions of bersaglieri were armed last July with a rifle similar to the Prussian needle-gun, with slight modifications. The English army has, since the beginning of the year, carried the Snider. The arming of the Danish army with the Remington rifle is also complete; and Russia makes the greatest efforts to hasten the supply to her troops of Carlen needle-guns. Of the other States, Holland, Sweden, Roumania, and Servia have only just introduced breech-loaders into their respective armies, while in Turkey, Spain, and Portugal the soldiers still carry the old musket.—*Cologne Gazette.*

U. S. Ordnance Report.—The expenditures of the Ordnance Department during the last fiscal year, for all purposes, inclusive of the payment of war claims, were a little more than three millions—less than three-fifths of the expenditure of the preceding year.

There are 27 military arsenals in all, including the National Armory at Springfield. The work done at them by the hired mechanics and enlisted men of the Ordnance Corps, under the direction of skilled officers of the corps, has been economically and satisfactorily performed.

Highly favorable reports of the breech-loading converted Springfield musket have been received from those portions of the army where it has been distributed.

A few smooth-bore and rifle guns, of heavy calibre, are being made, for trial of their power and endurance. When the most suitable kinds have been determined, a large number of guns for fortifications will have to be made, and authority to make them as fast as can be done is asked.

Torpedoes.—Further experiments have been made at Toulon with torpedoes, and it has been decided that in case of war, that port shall be strongly defended with these submarine monsters. The Government, however, thinks that the torpedo subject is one which should be confided to a special corps, and hence a school is to be established at the Isle of Aix, where the mysteries of those engines of destruction will be taught.—*Army and Navy Gazette.*

United States and British Squadrons.—At the date of the report of the Secretary of the Navy, we had on duty with our various squadrons, 38 vessels, including storeships, mounting in all 347 guns. On December 5th, the English had, within the limits of their several stations, 116 vessels, mounting in all 1,146 guns. From this it would appear that, besides their Channel fleet, the English have three cruising vessels in squadron service to our one.

New English Monitor.—The "Cerberus," recently launched at Jarrow, and designed by Mr. Reed, is 225 feet long by 45 feet 2 in. beam, and 18½ feet deep, the draft being 15½ feet. There are 2 turrets, 21¼ feet diameter. The turrets stand on central spindles and are revolved by auxiliary engines. Each turret carries two 18 ton 450 pdr. Armstrongs. The hull is divided into 7 water-tight compartments. The vessel is to go to Australia.

The Chronoscope.—A series of experiments carried out at Woolwich with the new chronoscope for measuring the velocity of projectiles within the bore of the gun invented by Captain A. Noble, late of the Royal Artillery, have been attended, it is said, with great success. The instrument has proved itself capable of measuring the hundred-thousandth part of a second with great accuracy.

Ordnance Experiments.—It is stated that Admiral Dahlgren, Chief of the Naval Bureau of Ordnance, will ask Congress for a limited appropriation to be used in experimental gunnery, as no appropriation has been made for this purpose for the Navy.

Krupp vs. Armstrong.—The German papers claim a decided victory for Krupp over Armstrong in the late trials of the rival systems. The English gun was shown to be inferior and split at the 264th round, while the German gun was fired 400 times without being damaged.

IRON AND STEEL NOTES.

Use of Manganese in Steel Making.—Mr. Robert Mushet, in replying to a paper on iron and steel by Messrs. Hinde, says:

In their remarks on the effect of spiegeleisen, and of the preparations of manganese with carbonaceous matters, as set forth in Vickers' and Heath's patents, Messrs. Hinde have gone completely astray, and have fallen into the common error of supposing that spiegeleisen is added to oxygenated iron solely to recarbonize such iron. The fallacy of this opinion has been clearly shown where ferro-manganese in place of spiegeleisen has been used to de-oxygenate molten Bessemer metal, the results obtained being far better than when spiegeleisen is employed. Now, ferro-manganese contains only about one-fifth as much carbon as spiegeleisen, and nearly four times as much manganese, and were it possible to produce pure metallic manganese free from carbon, at a cheap rate, it would wholly supersede spiegeleisen, and would enable manufacturers of Bessemer metal to obtain from inferior numbers of hematite pig metal, steel of as good a quality as they now obtain from best selected pigs. Nothing but metallic manganese requires to be imparted to oxygenated iron to produce steel, and the use of compounds containing other matters, is simply due to the fact that a better or purer form of metallic manganese than is contained in spiegeleisen cannot be economically procured. Neither under Heath's nor under Vickers' process is metallic manganese added to steel. Oxide of manganese is the agent here, and its action is that of a flux. Thus, when blister steel, which, when melted and cast into an ingot, cannot be drawn into a sound bar, or bear a welding heat, is melted with a few ounces of oxide of manganese without any carbonaceous matter being added, and then cast into an ingot, the ingot thus produced can be drawn into a sound bar of steel, which will forge and harden well, and bear a welding heat. In the melting pot, therefore, oxide of manganese, and not metallic manganese, acts as an improver of the steel operated upon. As to either Vickers' or Heath's process being applicable where it is desired to de-oxygenate decarbonized iron, it is a myth.

Park and Love's Steel Process.—This is an invention relating to the manufacture of cast-steel, and the furnaces used for that purpose, and also for remelting. The furnace consists of two fire chambers, separated by a fire bridge; one of these chambers receives a crucible, and the other contains a reverberatory fire chamber. Both chambers are in connection with the crucible, which is surrounded with fuel. The second chamber has a curved or arched top, to direct the flame into the crucible chamber to the fuel therein, or to the open mouth. The crucible is provided with discharge holes. After bringing both fires to a white heat, molten cast iron is poured into the crucible in such quantities as will form steel, together with malleable iron. Vitreous fluxes are introduced. Wrought-iron scraps, previously brought to a white heat in an adjoining furnace, are introduced into the cast-iron in the crucible. When the cast and wrought irons are mixed and melted together, the contents of the crucible are drawn off through the discharge holes. Puddling may be carried on in the furnace by making the working hole at the top instead of at the side. The puddling instrument is an iron ball on a bar, worked up and down by chain and pulley, or by hand.

James and Jones' Steel Process.—Messrs. James (of Ebbw Vale) and Jones (of Govilan) have specified a patent relating to the manufacture of steel, under which they claim the application of carbonizing and nitrogenizing gases under pressure to wrought iron in a receiver closed gas-tight. These gases are formed in a separate generator, and thence forced into the receiver through an accumulator or otherwise, or the gases may be formed in the receiver itself, partially or wholly. The nitrogenous gaseous compound preferred is cyanogen gas. They also claim the use under compression of blast-furnace waste gases, containing carbonic oxide, ammonia, and nitrogen; also other waste gases containing the necessary elements for the conversion of wrought iron into semi-steel or steel.

The Siemens-Martin Process.—Messrs. B. Samuelson & Co., of Middlesborough, write to "Engineering" that they do not (as had been stated) remelt the ingots produced by this process, but roll them, without hammering, into soft steel plates, capable of resisting a tensile strain of from 34 to 35 tons per square inch, and into rails which have withstood repeated blows of a weight of 21 cwt., falling from a height of 26 feet. As to the use of Cleveland iron—whilst it has not been possible to use it for the bath, they have, by Richardson, Johnson & Co.'s process of purification, succeeded in freeing the puddled bar, made out of Cleveland iron, from phosphorus to a sufficient extent to obtain the results stated.

The Temperatures (centigrade) best adapted to the tempering of various instruments are seen in the following table:

Lancets	210°—215°
Other surgical instruments	220
Razors	225
Penknives, erasers	230 —235
Scalpels, cold chisels for iron	240
Shears, sheep shears, gardening tools	250
Hatchets, axes, plane irons, pocket-knives	260 —265
Table knives, large scissors	270 —275
Swords, watch springs	285
Large springs, daggers, augers	290
Saws, some springs	310 —315
Various other instruments requiring less hardening	320

Chromium Steel.—It has long been known that an alloy of 60 parts of chromium and 40 parts of iron is so hard as to scratch glass like a diamond, and such an alloy may be formed by heating oxide of chromium in a blast-furnace with metallic iron. Experiments are now being carried on to produce a species of steel, suitable for rails and other purposes, by adding chrome ore and manganese to the iron in the puddling furnace; and the results are said to be promising, though not yet conclusive.

Creusot.—The Bessemer process is being introduced on a vast scale, and 80 new puddling furnaces are being added to this immense establishment.

Powder Hammer.—If the following, which has "gone the rounds," etc., for a year or so, *works*, a description of the apparatus, mould stoppers, strength of parts, etc., it will be gladly and prominently quoted and credited by Van Nostrand's Magazine: A French periodical states that Mr. Galy Cazalat has invented an ingenious process for compressing molten steel, intended for guns, so effectually as to save all the labor of hammering. In the upper part of the mould into which the metal is run is an apparatus containing a small quantity of highly inflammable powder, which, in burning, generates gas in such quantity as to produce thereby, in a short time, a pressure of ten atmospheres. This pressure expels the gases contained in the steel, and forces the metallic molecules into the closest union.

Iron or Steel Direct from the Ore.—In order to produce iron or steel direct from the ore, Mr. G. W. Nasarow, of St. Petersburgh, treats the ore with a solution of carbonate of soda in water, allowing the solution to stand a considerable time in contact with the ore. The weight of the carbonate of soda employed may be about one-fortieth part of the weight of the ore. The ore thus prepared is placed in a furnace—a reverberatory furnace supplied with a hot blast may be advantageously employed. The ore is melted down and iron or steel is obtained, according as the metal is allowed to remain in the furnace a longer or shorter time. The compact bloom obtained may be forged and rolled. Scrap iron may be treated in the same way, but in some cases it is necessary to add more carbon.

Iron from Pyrites.—Experiments are now being made in New York, with a view to the production of merchantable iron from pyrites. At a recent meeting of the Lyceum of Natural History, Professor Eggleston stated that the furnace employed is similar to an old Swedish furnace, very much cut away, and steam heat is employed; the material is kept in the lower part of furnace at a white heat, till agglutination takes place; the pasty mass is then skilfully worked and separated into grains, and afterwards withdrawn. He would not prejudge the case, but entertained no hopes of success.

Manufacture of Steel.—Puddled bar is converted into steel, according to the invention of Mr. V. Gallet (referred to in the *Mining Journal*), by coating the bars with a paste composed of wood charcoal, 20 parts; soot, 12; lamp-black, 15; ivory black, anthracite, plumbago, 1 each; carbonate of lime, 33; carbonate of potash, 3 to 20 parts; carbonate of soda, 10; caustic potash, sea salt, sal ammoniac, 1 each; clay, 13; oxide of manganese, 3; and resin, 3 parts—the whole combined with water. The iron is coated with the paste, and the cementation conducted in the usual manner.

Shotting Melted Metal, by pouring it into water, is largely practised, and is a very convenient way of reducing iron and steel for remelting. But if the mass of water is not very great compared with the mass of metal, and if it is not kept cool, the generation of steam will cause explosions. In several of the Bessemer steel works, where shotting steel for remelting in crucibles is practised, explosions of various intensity have occurred—some simply throwing up the water and bursting the tank. In Silesia, recently, a shotting tank burst, killing and wounding several men.

Cost of Bessemer Plant.—Much is being said, just now, in connection with new modes of making steel, of the great cost of the Bessemer plant. Yet a plant capable of turning out upwards of 12,000 tons yearly, or 250 tons weekly, viz., a pair of 5-ton converters, with all machinery complete, costs but £6,000; the interest upon which, together with fuel, attendance, repairs, and depreciation, would hardly amount to half-a-crown a ton, whereas the cost of ingot moulds alone, necessary in all steel melting, by whatever process ingots are made, is as much as 4s. per ton. Of the Bessemer plant the cost of a double-blowing engine, with a pair of 3 feet steam cylinders and 4½ feet blowing cylinders, with a stroke of 5 feet, is £1,800, or, with boilers, less than £2,500. As compared with the cost of machinery necessary to work the product of such a plant, its own cost is very little indeed. For, with £6,000 outlay for Bessemer plant, £80,000 or so would be expended in the hammers, rolls, engines, boilers, and miscellaneous machinery, requisite for working up 1,000 tons of ingots monthly into goods.—*Engineering.*

The Pennsylvania Steel Works.—It is now over a year since a charge of steel has been lost at these works through any failure of the machinery, tuyeres, vessel-bottoms, or refractory materials. To those familiar with the English practice, this will appear a remarkable result. It is due, of course, to good construction and careful management. The American refractory materials, as far as developed, are not equal to the English.

New Auxiliary to the Bessemer Process.—John Francis Bennett, of Pittsburgh, has patented the use of carbonic acid gas, either alone or mixed with atmospheric air, or with other gases or vapors, when introduced into molten iron or other metal for the purpose of removing sulphur, phosphorus, and any other impurities which will form combinations with the oxygen of the carbonic acid, and deposit the carbon. It is said that this process is about to be tried at the works of John Brown & Co., Sheffield.

Costly Steel-Making.—An invention explained at a recent Converzatione of the Institution of Civil Engineers, consists in grinding pig-iron to powder by a very rapidly revolving cutter. The great heat generated sets the particles of metal on fire, and after scintillating, they fall down in a reddish brown dust, which is gathered, placed in a crucible, and melted.

The Bethlehem Iron Co. have purchased the Northampton (new) furnace near their works, and are adding a foundry and a new rolling-mill, with Siemens furnaces, to their already extensive plant, viz.: 2 blast furnaces, a rail mill, producing 90 tons daily, and a very large machine shop.

The French Railway and Naval Blast Furnaces, Forges, and Steel Works Company have introduced the Bessemer process for the manufacture of steel in their Givors Works.

RAILWAY NOTES.

Railways in the United States.—The development of our railway system has been more rapid during 1868 than ever before. We have a nominal increase of 3,450 miles of road, costing $193,245,232. The actual figures are probably 3,000 miles at $150,000,000 cost. The following table shows the distribution of mileage and cost:—

	Miles of Road.		Cost of Road and Equipment.
	Total.	Open.	
Maine	944.19	559.67	$19,789,521
New Hampshire	783.72	668.72	21,975,319
Vermont	643.59	603.59	24,347,149
Massachusetts	1,537.36	1,4[illegible]5.43	68,345,521
Rhode Island	121.47	121.47	5,006.665
Connecticut	782.66	641.23	23,064,859
New York	4,459.58	3,328.87	182,538,123
New Jersey	984 75	972.75	69,770,243
Pennsylvania	4,937.72	4,397.74	256,772,257
Delaware and E. Maryland	362.90	242.94	7,483,596
Maryland (other than above)	654.95	457.45	28,520,899
West Virginia	605.85	364.75	22,404,100
Virginia	1,909.88	1,464.27	47,549,038
North Carolina	1.617.79	1,096.67	25,687,414
South Carolina	1,338.17	1,076.17	25.131,600
Georgia	1,977.60	1,574.60	31,369,075
Florida	613.20	440 20	9,294.000
Alabama	1,604.90	952.60	28,511,726
Mississippi	900.20	900.20	24,545,303
Louisiana	837.30	370.50	14,321,201
Texas	1,837.50	513.00	14,406,000
Arkansas	687.00	86.00	4.211,000
Tennessee	1,760 63	1,435.63	43,018,916
Kentucky	1,418.95	812.65	28,799,285
Ohio	4,053.44	3,351.97	169,014,101
Michigan	2.044.26	1,199.26	44,549,043
Indiana	3,246.10	2,600.10	104,229,226
Illinois	4,561.95	3,439.95	156,958,102
Wisconsin	1,773.60	1,234.60	48,469,301
Minnesota	1,758.00	571.50	18,460,000
Iowa	3,032.90	1,522.90	61,332,000
Nebraska	449.00	420.00	21,000,000
Wyoming Ter.	560.00	510.00	41.800,000
Missouri	1,837.09	1,353.80	64.014,458
Kansas	1,123.00	648.00	30,840.000
Colorado	350.00	....	350,000
Utah Ter.	305.00	105.00	9,400,000
Nevada	390.00	320.00	25,600,000
California	2,091.50	468.50	30,336.000
Oregon	2,019.50	19.50	500,000
Total Jan. 1, 1869	62,917.10	42,272 18	$1,853,706,041

Street railways, say 2,500 miles, and double tracks and sidings, say 25 to 30 per cent. on the whole, are not included in the above table. The total length of single track in the United States can therefore hardly fall short of 60,000 miles. This is the work of 40 years.—*Compiled from the Railroad Journal.*

British Railway Traffic and Maintenance Statistics.—The number of passengers carried in Great Britain in 1866, was 313,699,268, or an average of about 10 journeys by rail yearly for every man, woman, and child in Great Britain. In carrying these passengers 19,228 vehicles were employed, which ran 73,383,356 miles in 3,741,086 trains. It has been computed that to carry such a traffic under the told system would require about 50,000 coaches, and more than half a million of horses.

The number of persons travelling by railway in and out of London averages about 300,000 daily. Nearly 700 trains run over the Metropolitan line alone. The total number of local London trains per day is about 3,600, besides 340 trains which arrive from and depart to distant stations. During the busy hours of railway traffic, morning and evening, as many as 2,000 train stoppages are made hourly for the purpose of taking up and setting down passengers, while about 2 miles of railway are covered by running trains.

The annual loss of iron by tear and wear on the 13,854 miles of railway open for traffic in Great Britain amounts to above 20,000 tons a year, while about 250,000 tons require to be taken up, re-rolled, and relaid. The wooden sleepers, also, perish at the rate of about four millions per annum, to renew which about 10,000 acres of pine forest require to be cut down. To maintain the permanent way, about 81,000 men are constantly employed, at the rate of 5 men per 2 miles of double way. Besides these workmen, there are 13,000 plate-layers employed in laying down and fixing new rails; 40,000 artificers. who construct and repair the rolling stock; 26,000 porters, signalmen, and pointsmen; 6,000 guards and breaksmen; and 11,000 engine-drivers and firemen; or a total of about 177,000 railway workmen.

The heaviest item in the working expenses of railways is that for locomotive power. There were 8,125 locomotives at work in the United Kingdom in 1866, or about 2 engines for every 3 miles of railway open; and the work they performed during the year, was the haulage of 6 millions of trains a distance of 143 millions of miles.

The average working "life" of a locomotive is about 15 years, during which it will run about 300,000 miles, undergoing during that time many repairs and renewals; after which it may be considered used up, when it is sent to the scrap heap. Thus, taking into account the tear and wear of the locomotives at work in the United Kingdom, about 500 engines have to be replaced yearly; and as a good locomotive costs from £2,500 to £3,000, the expenditure on new engines amounts to about million and a quarter sterling yearly.

As to cost of working, a passenger engine will consume about 30 lb. weight of coke per mile, and a goods engine 45 lb. Hence the coal and coke used in 1866 was about two and a half million tons.

The average earnings of each locomotive amount to about £5,000 yearly, or equal to 5s. a train mile. According to a recognized formula, the working expense per train mile is 2s. 3d., which may be thus divided: 1s. for maintenance of stock, 3d. for maintenance of way, 9d. for coaching and goods expenses, and 3d. for miscellaneous expenses.—*The Quarterly Review.*

Fast Running.—A train on the Chicago and Northwestern recently made the unprecedented run of 91 miles in 90 minutes. The quickest prior runs of which we have any record are as follows: In England 18 miles by a special train in 15 minutes. In the United States, 14 miles in 11 minutes, by an engine and 6 cars, on the New York Central; 10 miles in 7¼ minutes, on the Pennsylvania Railroad; 144 miles in 2 hours 49 minutes, on the Hudson River road; 84 miles in 90 minutes, from Indianapolis to Union City; 305 miles in 7 hours 42 minutes, from Albany to Niagara.—*Exchange.*

Oregon Branch of the Pacific Railway.—It will require only about 330 miles of railroad to open a communication between the Union Pacific Railroad, near the north end of Salt Lake, and the city of Portland, in Oregon. The whole distance is 645 miles, but 300 can be travelled by steamboats on the Snake and Columbia rivers.

Permanent Way of the London Metropolitan Railway.—All the rails on this line are of steel, weighing 84 pounds per yard, and resting on sleepers placed about 2 feet 8 inches apart, centre to centre, and 1 foot 10 inches apart at the joints, which are made with fish plates, and 4 bolts seven-eighths inch. diameter. The sleepers are bedded upon 14½ inches screened gravel.

Turkish Railways.—The resources of Asiatic traffic are in a measure shown by the earnings of the Smyrna and Cassaba Railway, 61 miles long, now earning £2,000 a week, or nearly £33 per mile per week. During the week last reported, 4,696 passengers and 2,166 tons of goods were carried.

Railway Ferries are somewhat used in Great Britain. There is one across the Tay at Broughty, and one across the Forth at Granton. They are only for goods trains. The boats carry 25 short cars at a time.

Dutch Railways.—A new link in the line from Amsterdam to Paris was recently opened—the Utrecht and Waardenburg—and the whole line is promised to be completed by the end of this year.

Government and Railways.—A strong pressure is being brought to bear upon the British Government, in favor of buying the Irish railways upon terms submitted during the last session of Parliament by a joint committee.

MISCELLANEOUS.

Resources and Works of Pennsylvania.—The anthracite coal production of this State increased from 365 tons in 1820 to 12,650,671 tons in 1867. The bituminous coal field covers 1,300 square miles; the anthracite, 470. The production of pig iron, begun in 1720 in Chester county, has been increased and diffused until it amounted in 1867 to 839,496 tons. Pennsylvania is first among our States in the production of both coal and iron, and second only to Massachusetts in the range and extent of her manufacturing industry. She has 972 miles of canals, which cost $38,660,397, and 3,097 miles of completed railroads, which cost about $250,000,000, being foremost of all the States except possibly Illinois, in railroads, and before all but New York in canals.

Scale in Locomotive Boilers.—The locomotive superintendent of the Chicago and North-Western Railway, has for 3 years past succeeded, although using very hard water, in keeping his boilers free from scale by merely introducing once in about 3 months, 12 pounds of pure zinc, in pieces about one-half inch square. This appears to gradually clean the boiler, and to prevent the formation of fresh scale. The zinc wholly dissolves in from 3 to 5 months, and the inner surfaces of the boiler plates are then found covered with a thin coating of zinc, as are also the ends of screws taken out for examination.

Broken Screw Shafts.—It is but lately that the Hibernia was lost by the breaking of her screw shaft within the stern tube, the broken ends fouling and so forcing away the after-end of the shaft, thus admitting a flood of water into the hold. The Borussia, of the Hamburg American line, put back recently on her way to New York, with her screw shaft broken, but happily not inside the stern tube.

Strength of Corrugated Iron.—We devote this month more space than we shall ordinarily allow for a single article, to the comprehensive paper on this subject. It is a paper that can hardly be condensed, and as it is comparatively new matter, and likely to be frequently referred to, it will be more useful and convenient in this form, than if divided.

The New York Stock Yard at Communipaw covers, with its buildings, 15 acres of ground. The average market consumption of New York per week is, beeves, 5,500 ; of swine, about 21,000 ; of sheep and lambs, about 22,000. The capacity of this Abbatoir for slaughtering and dressing is : of beeves, from 6,000 to 7,000 ; of swine, upwards of 35,000 ; and of sheep, upwards of 25,000.

New Books.—Under this head we intend to give, each month, the titles of all prominent new books connected with Engineering, together with a very brief abstract of reviews of them by our contemporaries.

The New Dam at Cohoes across the Mohawk river will be the largest work of the kind in the State. It is 1,640 feet long, from 14 to 20 feet high, 16 to 18 feet wide at the bottom, and 10 at the top. Some 500 feet of the dam are completed.

St. Paul's Cathedral.—The total cost of the erection of St. Paul's Cathedral was £747,954 2s. 9d., less than $4,000,000. It is slightly larger than the New York Court House.

Steamship construction and engines will form the subject of a comprehensive article in the March number of this magazine.

The Coffer Dam at Rock Island, is seven-eighths of a mile long, and from 8 to 14 feet wide, and contains a million feet of lumber.

Small Locomotives for mines, quarries, stock yards, etc., to take the place of teams, are building by Grice & Long, Philadelphia.

NEW BOOKS.

Shipbuilding in Iron and Steel. A practical treatise giving full details of construction, processes of manufacture, and building arrangements ; with results of experiments on iron and steel, and on the strength and water tightness of riveted work. By E. J. Reed, C. B., Chief Constructor of the Navy, Vice President of the Institution of Naval Architects, and Honorary Member of the Liverpool Literary and Philosophical Society.

There are several excellent works, by distinguished authors, on this subject. Mr. Scott Russell and Professor Rankine, go very fully into stability and form of least resistance. Mr. Reed treats in a more comprehensive and practical manner of details of construction, and strength of materials and forms. The work is complete in one 8vo volume of 540 pages, and the excellent plan of having the illustrations inserted in the letter-press has been followed, thus avoiding the necessity for a separate volume of plates. There are upwards of 260 wood-cuts, and five steel plate engravings. The book is divided into chapters on the strength of iron ships : on keels, keelsons, and garboard strakes ; on stems ; on stern-posts ; systems of framing, in various chapters ; deck stringers and plating ; bulkheads ; topsides ; rudders ; iron masts ; steel plates for ship-building ; rivets ; testing iron and steel ; Lloyd's and rules for shipbuilding ; armor plating, etc. The best evidence that can be adduced in favor of the practical nature of the work is that the Lords of the Admiralty have directed that the examinations in practical iron shipbuilding of candidates for promotion in the Royal Dockyards will, in the main, be based upon Mr. Reed's treatise.

"Engineering" says of the work :

Not only is it distinguished by its essentially practical tone, and the fullness of the information it affords with respect to details, but it also contains several other novel features, which, in our opinion, are well worth notice. One of these consists in the fact that, instead of giving the usual historical sketch of the progress of iron shipbuilding, that progress is traced in the notices of the various parts of the ship. For example, in the chapter on "keels, keelsons, and garboard strakes," there is given an account of the steps by which shipbuilders passed from the wooden and hollow iron keels and keelsons of the early ships up to the present arrangements. This course is followed throughout the work, and has the further interest of sometimes showing how arrangements which had fallen into disuse had been re-applied recently. Before the appearance of this book, no accurate and detailed account of the changes made in the construction of iron-clads, from the time of the Warrior's building up to the present, had appeared. This want has, however, been supplied most satisfactorily in the present volume. We find in this volume, also, fuller notices of the practice of private builders with respect to the various parts of iron ships than have ever previously appeared. Scarcely any of the great firms remain unrepresented.

Sciography, or Radial Projection of Shadows. By R. Campbell Puckett, Ph. D., Head Master of the Bath School of Art. London : Chapman & Hall, 193 Piccadilly, 1868.

This work is well reviewed by the "Mechanics' Magazine," which says :

Sciography, or the science of shadows, has never received that special attention it deserves. This is evidenced by many architectural drawings, where the attempt to unite the mechanical projection of shadows with perspective representations, produces many errors, and shadows of the most impossible character. To correct this tendency by means of a text-book, has fallen to the lot of Dr. Puckett, who has well performed his part. The work is very properly limited to the perspective projection of shadows, and, therefore, pre-supposes a knowledge of linear perspective on the part of the student. It forms, therefore, a supplement to perspective studies.

The Mechanic's and Student's Guide in the Designing and Construction of General Machine Gearing, as eccentrics, screws, toothed wheels, &c., and the drawing of rectilineal and curved surfaces, with practical rules and details. Edited by Francis Herbert Joynson, author of "The Metals Used in Construction." Edinburgh: William P. Nimmo, 1868.

The "Building News" states that this book goes very fully and satisfactorily into the subject of shafting. The "Mechanics' Magazine" says: The student will find rules for the construction of the above parts of machinery, as well as practical rules and details for drawing rectilineal and curved surfaces. Of course, this work assumes an acquaintance with mechanical drawing. The details and calculations of shafts, pedestals, and pulleys, are carefully considered, after which we have a selection of geometrical problems. The volume is accompanied by eighteen sheets of diagrams.

A Practical Treatise on the Manufacture of Portland Cement. By Henry Reid, C. E. To which is added a Translation of M. A. Lipowitz's work, describing a new method adopted in Germany of manufacturing that cement. By W. F. Reid. London: E. & F. N. Spon, 48 Charing Cross. 1868.

"The Engineer" says this is an excellent and thoroughly practical treatise. The "New York Tribune" says: "Among the chief merits of the book are extensive plagiarisms from Major-General Gillmore's standard American treatise on Limes, Hydraulic Cements, and Mortars. We presume the profession in America are perfectly willing to furnish material for the writers of books on the other side of the water, provided due credit is given, and the ordinary courtesy among gentlemen is observed in the matter."

A Treatise on the Metallurgy of Iron. Containing outlines of the history of Iron Manufacture, methods of assay, and analyses of iron ores, processes of manufacture of iron and steel, etc. By H. Bauerman, F. G. S. First American edition revised and enlarged, with an appendix on the Martin process for making steel, from the report of Abram S. Hewitt, U. S. Commissioner to the Universal Exposition at Paris, 1867. Illustrated with numerous wood engravings. New York: Virtue & Yorston, D. Van Nostrand.

This work has already had a wide circulation, and is officially adopted as a regular book of reference in one of our best engineering schools. For a comparatively small and cheap book, it is perhaps the best and most thorough work in print, on this subject.

Examples of Modern Steam, Gas, and Air Engines. By John Bourne, C. E. London: Longmans, Green, Reader, & Dyer, Paternoster-row.

Parts VI. and VII. of this admirable treatise are now published. The author continues the discussion upon water-jet pumps and pumping engines. He then enters upon the subject of fire-engines. We next have a dissertation upon blowing engines. The plates which accompany parts VI. and VII. represent the slide, expansion and valve gear, and the boilers of R. M. S. "Russia," and the 15 horse power high pressure inverted screw engine, made at the Motala Iron Works, Sweden. The quality of Mr. Bourne's writings on the steam-engine and kindred subjects, is too well known to require comment.

Personal Recollections of English Engineers, and of the Introduction of the Railway System into the United Kingdom. By a Civil Engineer, Author of the "Trinity of Italy." London: Hodder & Stoughton, 27 Paternoster-row, 1868.

In closing a long review of this book the "Builder" says: The book which we have thus condensed will be found amusing, as well as instructive reading. Engineers and contractors will recognize in it many portraits, though the name be not written beneath the picture; and legislators will discover hints here and there deserving their attention. Other authorities do not consider the book as taking rank among scientific works.

Modern Screw Propulsion. By N. P. Burgh. London: E. & F. N. Spon, 48 Charing Cross.

This treatise has reached Part X., in which the chapter on the modern details of screw propellers is concluded, and an interesting chapter on bearings, by Mr. John Penn, is given. Particulars and engravings are given of the experiments and apparatus, by which Mr. Penn proved the practical utility of wood bearings when submerged in salt water. The 3 plates accompanying this part illustrate the geometry of the screw propeller, a 3 bladed twin screw propeller, and the geometry of the Griffith's screw propeller.

Irrigation in Southern Europe, being the report of a Tour of Inspection of the Irrigation Works of France, Spain, and Italy, undertaken in 1867–68 for the Government of India. By Lieutenant C. C. Scott Moncrieff, Royal Engineers Assoc. Inst. C. E. London: E. & F. N. Spon, 48 Charing Cross.

A Practical Treatise on Heat, as applied to the Useful Arts; for the use of Engineers, Architects, &c. By Thomas Box, Author of "Practical Hydraulics." London: E. & F. N. Spon, 48 Charing Cross. 1868.

This is pronounced by competent authorities to be a valuable work.

A Manual of Practical Assaying. By John Mitchell, F. C. S. Third edition, edited by William Crookes, F. R. S., etc. London: Longman, 1868.

This is a new and much enlarged edition of a standard work. It is an octavo volume of 780 pages.

A Practical Treatise on Metallurgy, adapted from the last German edition of Prof. Kerl's Metallurgy. By Wm. Crookes, F. R. S., etc., and Ernst Rohrig, Ph. D., M. E. London: Longmans, 1868.

VAN NOSTRAND'S
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HISTORY OF DECARBURIZING IRON.

The subject of greatest interest, at this time, to the engineering profession, and to the public (excepting only the construction of the new Cabinet), is the cheapening of iron in a malleable form. The success of the Ellershausen process of making malleable* pig-blooms, by mixing ore with iron as it runs from the blast furnace, has stimulated an amount of experimenting entirely unprecedented in the history of the iron manufacture. We venture to say, that in every considerable iron works in the United States, the ore process has been more or less tried, in some form, during the last three months, and that in at least half these establishments the Ellershausen turn-table, or some other mixing apparatus is in process of construction or in experimental use.

Nitrates, for decarburizing crude iron, are also the subject of experiments, either upon the plan of Heaton, or as an auxiliary to puddling. Nearly every expert in iron working has a scheme of his own, and the Patent-office is getting as crowded with iron and steel papers as with claims for velocipedes.

Just at this time, therefore, an abstract of the history of purifying crude iron, will be read, we think, not only with interest, but with profit. Many thousands of dollars that would otherwise be wasted in the attempt to patent processes that are old, may be saved by a careful reference to patents already in existence. The official and most carefully prepared abstracts of specifications, issued by the British Patent-office, may be fairly presumed to embrace nearly every invention of value. Probably no process of sufficient novelty to become the subject of a patent, has remained unprotected, and the British list is likely to embrace the inventions not only of Britain, but of America, France and Germany, because improvements in the iron manufacture are worth more, and will pay better, in England, than in any other country. American inventors generally obtain patents in England first, to be certain of securing their claims there. Of course there are many experiments that never become the subject of patents or publications—but mere experiments that have not been able to lead to successful practice, are no bar to the issue of patents to other and successful experimenters with the same means and in the same direction. And although the publication of the many unrecorded trials and schemes that have been made and suggested would be of interest, it would not be of very great value as compared with a record of patented inventions; there is certainly no means of getting at the unrecorded schemes, except the laborious and costly means of patent suits, which from time to time call up some of the more important ones—generally with little practical effect.

We propose to give abstracts of the "Abridgements of the Specifications relating to the Manufacture of Iron and Steel," in the department of decarburizing and purifying crude iron so as to make it malleable and tenacious. For convenience of reference we shall prefix to each abstract a very brief statement of what the patent is about—the *gist* of the matter; and although

* That is to say, malleable after being sufficiently heated to be got into the form of a puddle ball.

we shall omit all merely formal parts, we shall quote, in the words of the patent itself, all those statements that form the essence of the invention, and would be the subjects of legal claims.

DECARBURIZATION AND PURIFICATION BY MEANS OF CINDER, ASHES, SALT, SILEX, POTASH AND CLAY.

PAYNE, JOHN.—1728, Nov. 21. No. 505.

The improvements in the manufacture of iron consist "in putting certain ingredients into fusion with pig or sow iron; videlicet, the ashes of wood and other vegetables, all kinds of glass and sand-ever, common salt and rock salt, argile, kelp, and pot ash, slegg or cinders from iron furnaces, and forges, proportionable parts of the said ingredients being put into fusion or melted with pig, sow, or other brittle iron, which will make the like change as charcoal does in the fire called the finery in common forges, and will render the same into a state of malleability, as to bear the stroke of the hammer, to draw it into barrs or other forms att the pleasure of the workman, and those or other barrs being heated in the said melted ingredients in a long hott arch or cavern, as hereafter is described; and those or other bars are to pass between two large mettall rowlers (which have proper notches or furrows upon their surfass), by the force of my engine hereafter described or other power, into such shapes and forms as shall be required."

NOTE.—*The "finery" referred to is the run out or fining fire still in use in England—blowing air down upon melted iron to partially decarburize it preparatory to farther refinement. The Bessemer process is a vast enlargement of this idea.*

The "long hott arch" described in another part of the patent, is a reverberatory furnace. This subject and other features of the iron manufacture will be taken up in another series of articles.

Kelp is calcined sea-weed ash. "Argile" or argil is alumina.

FINERY IRON MIXED WITH SLAG, SCALES, SAND, LIME AND OTHER FLUXES, AND SOMETIMES WITH MALLEABLE SCRAP, AND MELTED IN CRUCIBLES.

WOOD, JOHN.—1761, Feb. 5. No. 759.

"A way of making malleable iron from pig or sow metal" and of making "the malleable iron hard or soft or of other required qualities," by "raw pitt coal," some of the operations being "preparatory" and others "peculiarly essential."

The pig iron when prepared as hereinafter mentioned, is put into close vessels of clay and mixed with the fluxes. The crucibles being hermetically sealed, are placed in an air furnace, and their contents are melted; the fluxes and impurities form slag, and "the iron is brought into a tough and malleable state," and then is wrought into bars under the forge hammer. The preparatory operations are,—

1st. "I take pig or sow iron." "This I flourish or heat and work in a common finery, with a blast" and coal fire until it is refined and "brought near to a malleable state," or brought to nature. It is then melted in the close vessels above described.

2d. "To the iron thus flourished I sometimes add a due proportion of small pieces of malleable iron, when the cast metal" is very brittle, and the coals very sulphurous.

3d. "I also take the same cast metal, and melt it down in an air furnace," and then I reduce it "into small grains (according to art) by pouring it into water upon a wheel or roller turned briskly round. The granulated metal" is "mixed with various fluxes, according to its nature and the uses for which the iron is intended, as with iron slag or cinder, scales or scoria of iron, fusible sand and lime, kelp, soaper's waste." The fluxes or additions "I put with the granulated metal into close vessels, and work" in the air furnace, as above described.

4th. The cast iron is sometimes "formed into thin plates," which are broken "into small pieces and put into the pots," with "due proportion of fluxes," and so "reduced to a malleable state."

NOTE.—*Mixing wrought iron scrap with cast iron finds its practical development in the Siemens-Marten process.*

The granulation of iron by means of water and the revolving table, is now practised in preparing iron for crucible steel making and other purposes.

The soaper's waste referred to, is wood ashes containing potash or soda.

The "raw pitt coal" referred to in the title, is used in the finery.

MAKING CAST IRON MALLEABLE WITHOUT BLAST, BY GRANULATING IT AND REPEATEDLY MELTING IT IN POTS WITH CINDER, SCALES, SAND, LIME, ASHES AND OTHER FLUXES, AND SOMETIMES WITH SCULL OR SCRAP IRON.

WOOD, JOHN AND CHARLES.—1763, July 29. No. 794.

The pig iron is either granulated by being poured hot into cold water, or pounded with heavy stampers. Scull or cinder is pounded in like manner. If the iron be of red short quality it is sprinkled with strong lee of kelp, and then flourished or melted in closed pots with proper fluxes, such as slag scales or scoria of iron, sand, lime, kelp, or soaper's waste.

If this operation does not sufficiently flourish or reduce the iron to nature, it is again broken by the stampers, and flourished a second or third time.

The iron is then again pounded, and sometimes mixed with pure scull or scrap iron, and is fit for chaffing or melting in the close pots, with a covering of clay, when it becomes "perfectly tough and malleable," and is to be "wrought under the hammer into half blooms."

MAKING PIG IRON MALLEABLE IN A REVERBERATORY OR AIR FURNACE WITH RAW PIT ONLY.

CRANAGE, THOMAS AND GEORGE.—1766, June 17. No. 851.

"The pig iron is put into a reverberatory or air furnace, built of proper construction, and, without the addition of anything more than common raw pit coal, is converted into good malleable iron, and being taken red hot from the reverberatory furnace to the forge hammer, is drawn into bars of various shapes and sizes, according to the will of the workman."

NOTE.—*We here see the importance of considering the state of the art at the time when the invention was made. After Cort had invented puddling, Cranage's specification would have been, in general terms, a description of that important invention. But before Cort's specification was issued (see abstract of it further on) we doubt if Cranage's would have guided any one "skilled in the art," to puddling. The two words "is converted" stand for the whole process of stirring up the iron with the rabble. The use of raw pit coal, which gave such great value to Cort's invention, is, however, mentioned. (See Percy's Metallurgy, Iron and Steel, p.* 636.)

MORE RAPID DECARBURIZATION IN THE FINERY BY THE USE OF MORE TUYERES AND A MORE DIFFUSED AIR BLAST.

COCKSHUTT, JOHN.–1771, May 2. No. 988.

The patent first describes making malleable iron (if "right managed") in the finery, from ore mixed with cinder.

Pig iron is made into wrought iron by heating sufficient for a bloom or loup in an air furnace, or with bellows. The heated metal is then put into a finery or bloomery, and melted with charcoal until it comes to nature, when it is sunk into a bloom and another charge is supplied. The finery is made of metal plates, open on two or more sides, so that men may work at least on two sides. "Instead of having only one tuiron" for the blast, there are "several tuirons, so as to direct the wind from the bellows to operate upon the iron in every part of the fire." The number of tuirons is regulated according to the nature of the iron. "This new finery, and new method of working, requiring a greater supply of wind than the common way," an air reservoir with valves is constructed to regulate the blast, the supply being provided by the requisite number of bellows.

NOTE.—*Ninety-eight years ago this iron worker had a better appreciation of the theory of air refining, which has since been so successfully worked out by Bessemer, than some of Bessemer's competitors have to-day. The idea of diffused blast is one of the leading ideas of Bessemer's invention, and if Cockshutt had blown a little harder, so as to penetrate the metal, he would have made a loup malleable in whole or in part, but he would not, of course, with any means then known, have produced his malleable metal in a liquid state. Some of the early claimants of the Bessemer invention used but one tuyere, and did not diffuse the blast.*

MAKING "STEEL" OR A HIGH IRON LIKE PUDDLED STEEL DIRECTLY FROM PIG IRON IN A BLOOMERY.

GOODYEAR, JAMES.—1771, Dec. 20. No. 1,000.

"Place the pig or cast iron in the fire as when you intend to make bar iron, but the blast of the bellows must not be so strong. When some of the iron is sunk in the fire you must work from the bottom as when you make iron, but keep melting iron as at first. When there is a sufficient quantity to make a loup let the whole sink to the bottom," when it may be fused and shingled, and drawn as common iron. "The fire must be kept as free from cinder as possible. The addition of common salt and other saline substances," and animal or charcoal dust, improves the steel. "The finest steel, after it is made as above, may be converted in the same manner as common steel is made from bar iron."

NOTE.—*The decarburized iron appears to be recarburized by keeping the pig iron melting above it after it is sunk in a loup, and also by charcoal dust, and it may be further recarburized by "converting."*

Steel is here mentioned by name, for the first time in the patent records.

MAKING MALLEABLE IRON FROM PIG, WITH RAW COAL OR COKE, WITHOUT GRANULATIONS OR ADMIXTURES, FROM BROKEN AND WASHED FINERY IRON.

JESSON, RICHARD, AND WRIGHT, JOHN. —Oct. 30, 1773. No. 1,045.

Pig iron, or scull or cinder iron, is melted in a finery with blast and with raw coal only, and taken out in lumps while hot, beaten into plates by a flat stamp or hammer, broken small and well washed by hand or in a rolling barrel. The broken metal is then melted in an air furnace or in closed pots and then "beaten into bars from a chaffery in the common way." If the metal be red short or cold short, it is mixed in the pots with the proper quantity of scrap or nutt iron.

NOTE.—*There appears to be nothing new or feasible here, except the washing in a rolling barrel, if red short iron, which the patentee mentions, was used; the lumps taken out of the finery and hammered would not require much farther breaking up, even if the carbon were sufficiently removed to render the mass malleable. If he made this process work, he has not told us how.*

FLUID IRON FROM THE SMELTING FURNACE STIRRED AND WORKED (AND IT WOULD APPEAR) PUDDLED IN AN AIR FURNACE BY THE AID OF AIR BLAST AND WATERY VAPOR.

ONIONS, PETER.—1773, May 7. No. 1,370.

Two furnaces are used, a common smelting furnace and another furnace of stone and brick, "bound with ironwork and well annealed," into which the fluid iron or metal is received from the smelting furnace. "A quantity or stream of cold water is run or put into the cistern or trough under the ash-grate." The furnace is then charged with fuel and closed up, and the doors luted with sand. The blast is then admitted below the grate, and when the furnace is sufficiently heated the liquid iron metal is taken from the smelting furnace in ladles, and introduced through an aperture, which is then closed. The blast and fire are then used "until the metal becomes less fluid and thickens into a kind of paste, which the workman by opening the door turns and stirs with a bar or other iron instrument, and then closes the aperture again, and must apply the blast and fire until there is a ferment in the metal." If no ferment ensues, a blast of cold air is to be blown upon the metal from an extra pipe. "As the workman stirs the metal" the scoria will separate, "and the particles of iron will adhere," these the workman "must collect or gather into a mass or lump." This is to be reheated to a white heat, and then taken to the forge hammer and forged into malleable iron. Instead of running fluid metal into the furnace, pig iron may be placed and melted there, and operated upon as above described. The forge hammer is connected with an air cylinder whose piston is attached to the helve, and is worked by it. The cylinder is either placed above the helve and acts as a buffer on the compression principle, or is placed below and on the exhaust principle draws down the hammer.

NOTE.—*It is difficult to see, from the patent records, why this patent does not in a great degree anticipate Cort's. Onions' drawings show a reverberatory furnace, and not a bloomery or finery fire in which the fuel and iron might be mixed together. The stirring with a bar, the ensuing fermentation, the coming to nature and the aggregation of the puddle ball, are distinctly described. (See also Percy's Metallurgy, Iron and Steel, page* 638.)

The direct blast of air would not be considered an element in puddling, as explained now-a-days by Mr. Siemens. (See Van Nostrand's Mag., Vol. 1, *No.* 1, *page* 38.)

A considerable quantity of steam must have been formed under the grate, and passed over with the flame. The modern Pomeroy process revives this practice.

*Peter Onions was a successful iron maker; his knowledge of the subject—*96 *years ago—was certainly in advance of the times.*

PUDDLING.

CORT, HENRY.—1784, Feb. 13. No. 1,420.

On Jan. 17, 1783, Mr. Cort patented a process of faggoting bar iron and of welding by *rolling in grooved rollers.* The title of the puddling patent of 1784 is as follows: "Shingling, welding, and manufacturing iron and steel into bars, plates, rods, and otherwise, of purer quality in larger quantities by a more effectual application of fires and machinery, and with greater yield than any method before attained or put in practice."

The patentee uses a reverberatory furnace heated by coal, having a concave bottom, into which the fluid metal is run from the furnace, or pig iron is put in and melted. When the workman discovers, by looking through a hole, that the metal is sufficiently melted, he opens an aperture, by preference, in the bottom of the door, and works and stirs up the mass of metal with iron bars, "which operation is continued, as may be requisite, during the remainder of the process." An ebullition of the metal soon takes place, and the stirring with the bar is continued till the metal is "flourished and brought to nature," when it is collected in loops and drawn out of the door. All small pieces that may happen to remain are cleared away. These with scull and parings and nut iron may be thrown into the furnace and worked up with the iron while it is being brought to nature. The iron so prepared may be stamped into plates, broken, piled, and worked in an air furnace, in pots, or without. "But the method invented by me is to continue the loops in the same," "or reheat them" in another air furnace to a welding heat, and then shingle them into half blooms or slabs. These may be heated in the chaffery, "but my new invention is to put them again in the same or another air furnace" from which the half blooms or slabs are taken, and either drawn down under the hammer or rolled through grooved rollers at a welding heat. Iron and steel so prepared is of good quality, whether the blistered steel be made from fagoted iron or from iron made by the above process. "The whole method" is "completed without using finery, charcoal, cokes, chaffery, or hollow fire without requiring any blast" or "the use of fluxes."

NOTE.—*This patent, and the patents of Nielson, (hot blast), Heath (carburet of manganese in steel making), Bessemer, Mushet, (recarburization), Siemens, and we may perhaps add, the process of Ellershausen, are the most remarkable in the history of the iron manufacture. With the exception of Bessemer's process, Cort's has made a greater revolution in refining iron, and has stimulated and cheapened production in a greater degree than any other process.*

Puddling "without the use of fluxes," however, as specially stated by Cort, has already gone out of use, and the improvements that are created by or will grow out of the Ellershausen process, are likely to revolutionize puddling to as great a degree as puddling revolutionized blooming. In the best practice, the ore used in fettling supplies the waste caused by the oxidation of iron in the puddling furnace, and improves the quality of the product. More recent experiments in the puddling furnace, with as much as 30 *per cent of ore, pulverized and worked into the melted iron, have increased the yield from six to eight heats per day, thus decreasing the cost, and at the same time making good the waste of iron, and improving the quality of the product.*

(To be continued.)

EMPLOYMENT OF COTTON WASTE AS MANURE.—M. Dupont-Poulet, a French cotton spinner, has for the last ten years used his cotton waste for seed beds and early crops. He mixes it carefully with stable manure, and thus avoids, as he says, the burning and the chills which manure alone often causes. M. Dupont-Poulet's example has been followed by his neighbors, some of whom have gone beyond him; one of them had the idea of using cotton in the forcing of asparagus, that is to say, he spread a layer of cotton waste, about eight inches thick, over one of his asparagus beds, and found that the snow when falling upon it disappeared very rapidly; he was able, without any other covering but the cotton, to gather fine, tender, well-flavoured asparagus in the midst of winter.

POWER CONSUMED BY DRILLS.

EXTRACTS FROM A REPORT BY CAPTAIN CLARINOAL, PROFESSOR IN THE ARTILLERY AND ENGINEERS' SCHOOL AT METZ.

Translated by John B. Pearse.

In order to ascertain the power required to bore a hole of given diameter in wrought iron, the following points must be considered: The kind of iron, the direction in which the hole is bored, its depth and diameter, the lubricating material, the form of the drill and its speed. The experiments were conducted with an ordinary drill press, while the power consumed was measured by Morin's dynamometer. The wrought irons used in the experiments were a very hard variety, forged under the steam hammer at the forges at Montigny-les-Metz, and a soft rolled iron from the iron works at Abainville. The drills used were center-bits and a flat drill of exactly equal diameter, driven at the same speed, and lubricated with oil and afterwards with soap-suds. Cast iron, bronze and steel were then similarly experimented on. The conclusions derived from the above experiments were the following:

(1.) The amount of power necessary to drill with a center-bit into wrought iron, remains quite constant so long as the depth of the hole does not exceed 0.05 meter: as soon as this limit is passed the required power increases rapidly.

(2.) The power consumed in boring across the fibres is almost independent of the depth of the hole; the original power is, however, somewhat greater than that required to drill in the other direction. Since however the power required in boring in the latter direction increases greatly with the depth, the total power required to bore a given hole across is much less than that required to bore it in the direction of the fibres.

(3.) The power required to bore a hole of given diameter increases with the hardness of the iron. The use of oil to lubricate the drill diminished the power required about 0.2, as compared with that required when soap-suds were used. This holds good as well in hard as in soft wrought iron.

(4.) The results obtained with center bits hold good also for flat drills; the latter, however, require a greater power than the former, as is shown below.

(*a*.) The power required by a flat drill 0.025 meter in diameter, to bore a hole in the direction of the fibre, is about 1.25 times as great as that required by a center bit of similar diameter operating under similar circumstances.

(*b*.) The power required by a flat drill, 0.025 meter in diameter, to bore across the fibres, is about 1.4 times as much as that required under similar circumstances by a center bit.

(*c*.) When the diameter of the drills is 0.015 meter the above quantities become 1.6 and 1.8 respectively, which seems to show that small drills require a comparatively greater power than large ones. When the diameter of the drills is 0.008 meter, the above proportion becomes 1.52, which corroborates the above conclusion.

These results agree with practice, since the flat drill is commonly used only for holes 0.008 meter in diameter, and under, which do not permit the use of the center bit or pin drill.

EFFECT OF VELOCITY.—In order to estimate the effect of the velocity of the drill, a drill of 0.025 meter was driven at a speed (on its circumference) of 0.22 meter per second, and also at a speed of 0.125 meter. The power consumed per second is clearly less at a slow speed than at a high one, but the power required to bore a given hole is about the same in each case. For instance, the power required to bore a hole 0.0074 meter deep (in the direction of the fibres) at a speed of 0.22 meter, amounted to 23.49 meter-kilogrammes, and to 21.8 at a speed of 0.125 meter: across the fibres, the power required at the high speed was 24.3 meter kilogrammes, and 22.3 at the low speed.

It appears then that the power required to drive the drill at either speed is not very materially different. Hence, the reporter concludes that the speed of the drill should be as great as possible, to diminish the resistance offered by the metal, and that the feed should be heavy, and both so far as possible without destroying the edge or boring too rough a hole.

The average advisable circumference speed of drills is 0.12 meter per second in wrought iron, 0.06 meter in cast iron and 0.15 to 0.18 in bronze (gun metal). When these velocities are exceeded the drill is apt to become soft, and when they are not reached the work is not economical.

The pulleys of the drill press used for these experiments are so calculated that the following circumference speeds of drills could be obtained:

	Millimeter.	Millim.	Milim.
Diameter of drill...	3 to 10	10 to 20	20 to 25
Speed at circumference............	34 to 115	77 to 154	104 to 183
Feed	16	10	7.5 milim. per min.

POWER DEMANDED BY BORING MACHINES.—As the hardest wrought iron necessitates the most power, M. Clarinoal based his experiments on that forged at Montigny, which is generally acknowledged to be very hard, and compiled the following tables from the results of numerous experiments on this wrought iron, on east iron and on bronze. The first table denotes the power required by a center-bit in boring a hole of given diameter and depth, while the second table gives the eorresponding results in the case of a flat drill.

Table showing power required in one second by a center-bit boring at different depths in hard wrought iron, ordinary gray cast iron, and gun metal (11 *parts tin and* 100 *parts copper*), *the feed being one millimeter per minute.*

Depth of hole.	HARD WROUGHT IRON. Diameter of hole.						ORDINARY GRAY CAST IRON. Diameter of hole.					GUN METAL. Diameter of hole.				
	44 millim.	35 millim.	25 millim.	15 millim.	10 millim.	8 millim.	35 millim.	25 millim.	15 millim.	10 millim.	8 millim.	45 millim.	40 millim.	25 millim.	15 millim	8 millim.
Milim.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.
5	11	7.4	4.7	2.23	1 85	1.57	3.6	2.9	1.1	0.6	0.5	6 1	6.	2.4	1.	0.4
10	11	7.4	4.7	2.23	1.85	1.57	3.6	2.9	1.1	0.6	0.5	6.1	6.	2.4	1.1	0.4
15	11	7.6	4.7	2.23	1.85	1.57	3.6	2.9	1 1	0.6	0.5	6.1	6.	2.4	1.2	0.5
20	11	7.6	4.7	2.23	1.85	1.57	3.6	2.9	1 1	0.6	0.55	6.2	6.1	2.45	1.3	0.6
25	11	7.6	4.7	2.23	1.85	1.60	3.6	2.9	1.1	0.6	0.60	6.2	6.2	2.5	1.5	0.7
30	11	7.9	4.8	2.23	1.85	1.63	3.6	2.9	1.1	0.6	0.67	6.4	6.3	2.6	1.7	....
35	12	8.3	4.8	2.24	1.90	1.66	3.6	2.9	1.1	....	....	6.5	6.4	2.7	1.9	....
40	13	8.8	4.9	2.25	1.90	1.70	3.6	2.9	1.1	....	....	6.6	6.4	2.8	2	....
45	14	9.6	4.9	2.30	....	1.75	3.6	2.9	1.1	....	....	6.6	....	2.9	2.3	....
50	....	....	5.	2.35	....	1.80	3.6	2.9	1.1	....	....	6.7	....	3.	2.5	....
55	....	....	5.	2.40	....	1.90	3.6	....	....	....	....	6.7	....	....	2 7	....
60	....	....	5.1	2.45	....	2.	3.7	....	....	....	....	6.8	....	....	2.9	....
65	....	....	5.2	2.50	....	....	....	....	....	....	....	6.8	....	....	3.1	....
70	....	....	5.3	2.70	....	....	....	....	....	....	....	....	....	....	....	....
75	....	....	....	2.80	....	....	....	....	....	....	....	....	....	....	....	....
80	....	....	....	3.	....	....	....	....	....	....	....	....	....	....	....	....
	Lubricated with soap-suds.						Bored dry.					Bored dry.				

Table showing power required in one second, by a flat drill, boring at different depths in hard wrought iron, ordinary gray iron, and gun metal (11 *parts tin and* 100 *parts copper*), *the feed being one millimeter per minute.*

DEPTH OF HOLE.	HARD WROUGHT IRON. Diameter of hole.			ORDINARY GRAY CAST IRON. Diameter of hole.		GUN METAL. Diameter of hole.	
	7.5 millim.	5.5 millim.	3 millim.	7.5 millim.	5.5 millim.	7.5 millim.	5.5 millim.
Millimeter.	Meterkilogramme.	Meterkilogramme.	Meterkilogramme.	Meterkilogramme.	Meterkilogramme.	Meterkilogramme.	Meterkilogramme.
5	1.9	1.5	1.2	1.08	1.	0.6	0.5
10	2.	3.	1.8	1.08	1.	1.	0.7
15	2.3	3.5	2.4	1.08	1.	1.2	0.9
20	3.	4.	....	1.08	1.	1.4	1.1
25	8.	5.	....	1.08	1.	1.9	1.7
30	9.	....	....	....	....	2.4	2.1
	Lubricated with soap-suds.			Bored dry.		Bored dry.	

As the results in wrought iron apply to hard iron, they should, according to M. Clarinoal, be diminished by about one-tenth to apply to soft wrought iron; and as the experiments were made with soap-suds as lubricating material, the powers given should be diminished, say one-fifth, when oil is used as the lubricator.

In the above tables, the power consumed by boring the given holes with a feed of *one millimeter per minute*, is taken as unity. Therefore, to ascertain the power required *in a second*, with a given feed, it is only necessary to multiply the figures in the tables *by the depth fed per minute.*

A comparison of results obtained with borers of both kinds of the same diameter (0.25 meter), shows that the power required to drive a flat drill in cast iron is 2.6 times as much as that required to drive a center bit.

Experiments on hard white cast iron, showed that the power required to drill such iron was very nearly double that stated for gray cast iron. It appears from the tables that the power required to drill cast iron is nearly constant, no matter what the depth of the hole may be.

The experiments made on steel showed that, under similar circumstances, more power was required to drill shear or soft steel than to drill hard cast steel, and that flat drills increased the power necessary by at least one-third ($\frac{1}{3}$).

Capt. Clarinoal concludes with the following remarks:

(1.) Nearly the same power is required to drill hard wrought iron and hard cast steel.

(2.) The power required to bore soft steel is not much greater than that required for hard wrought iron, but the former increases rapidly with the depth of the hole. Thus, at a depth of five or six millimeters, the power consumed in drilling with soap-suds in soft steel, a hole fifteen millimeters in diameter, is equal to that consumed in boring one of twenty-five millimeters in diameter in hard wrought iron.

HYDRAULIC PIPE ENGINEERING. — Messrs. Walsh and Watkins, contractors, have laid a 11-inch plate iron water-pipe, from a point on a mountain side in Tuolumne county, California, down the mountain, under a creek and up the ascent on the other side, in all 8,800 feet in length, and under a perpendicular pressure at the lowest point of 684 feet.—*Mining and Scientific Press.*

PURIFYING IRON ORES.

ON FLUOR SPAR AS AN AGENT FOR PURIFYING IRON ORES CONTAINING PHOSPHORUS.

By H. CARON.

Translated by John B. Pearse, from "Comptes Rendus" and "Berg and Hütten Zeitung."

I have already had the honor of communinicating to the Academy the results of my attempt to improve those pig irons which are smelted from non-manganiferous ores, which ores form a great part of those occurring in France. I was enabled to show by exact experiments that the addition of manganese (in the form of its oxides) to the furnace charges had the effect of removing or keeping out of the iron an appreciable quantity of the sulphur and silicium present in the ores and fuel. Since that time the experiments of the laboratory have been carried out in the trade, and there are now few furnaces where the addition of the oxides of manganese has not brought about a marked improvement in the quality of the pig metal.

I found at that time that the oxides of manganese had no effect in carrying off phosphorus, although they acted so favorably upon sulphur and silicium. I therefore endeavored to find some means of effecting the removal of the former body, and now confine myself to the communication of the only method which has given satisfactory and certain results.

The ores of iron which contain phosphorus, contain it principally in the form of phosphates of iron, alumina or lime; in order to combat the evil effects of these phosphates it was customary to mix large quantities of lime with the ores, as lime was commonly supposed to have some effect in this direction. Unfortunately, however, these phosphates of lime are slightly, or rather not at all fusible, and the addition of large quantities of silicious ore was necessary to cause the slag to flow readily.

What is now the result in the blast furnace? Phosphates, silicia and carbon are in immediate contact—just as in Wökler's method of preparing phosphorus; there result therefore silicious slag and iron, carbon and free phosphorus, which latter naturally combine to form a cold short pig metal. It is certain that this re-action actually occurs in the furnace as the analysis of slags, from ores containing a good deal of phosphorus, show very little of this element, while it is very rare that the same is not present in injurious quantity in the iron. Let us suppose that lime takes up the phosphorus of the ores, the problem then before us is to find some fusible substance which contains no silica, and can dissolve the phosphate of lime, without decomposing it. It seemed *a priori*, as if fluor spar was such a substance, and I endeavored to ascertain its virtues as follows:

(1.) A mixture of phosphate of lime and fluor spar was placed in a crucible of compressed coke, which was placed in a clay crucible and surrounded with charcoal.

(2.) A mixture of phosphate of lime with silica was placed in a similar crucible. Both crucibles were then exposed to the heat of a cast steel furnace, with the following results: The crucible containing the phosphate of lime with silica was eaten completely through, and the phosphorus had disappeared. The other crucible, on the contrary, was whole, merely a little of the coke alone having been melted off; the fused mass contained phosphorus and phosphoresced when struck with a hammer. It was therefore certain that fluor spar dissolved the phosphate of lime without decomposing it.

I accordingly experimented as follows upon phosphate of iron:

(1.) A mixture of phosphate of iron with lime and fluor spar, was placed in a brasqued crucible.

(2.) A mixture of phosphate of iron with lime and silica, was also placed in a similar crucible.

These mixtures treated as before gave the subjoined results. The crucible containing silica was eaten through, and the graphitic button of iron was easily broken up under the hammer. The other crucible was whole, and the resulting button was somewhat flattened out before it could be broken up, while the fracture showed that the iron was mottled. The first button contained three (3) times as much phosphorus as the second, which on being remelted became entirely white. The influence of the fluor spar was therefore established beyond a doubt.

On operating analogously upon ores containing phosphorus, which always contain a comparatively small quantity of phosphates, an appreciable improvement resulted from the substitution of the fluor spar for silica, although the improvement became less marked, the less phosphorus the ore contained. Not only are these phosphates soluble in fluor spar but also sulphates and arseniates; even alumina is taken up by this agent and retained in the slag without the aid of silica.

GOVERNMENT CONTROL OF TELEGRAPHS IN ENGLAND.—The acquisition of the telegraphs of the United Kingdom by the Government, and their being placed under the Post-Office administration, had been mooted for some time; last spring, action began to be taken and inquiries made; the result has been a large correspondence and cross-fire of pamphlets between the Post-Office and telegraph companies. This cleared the way for the government bill, which, after being committed, and much time spent in discussing and amending its objects, finally passed both Houses of Parliament and became a law. It empowered the Post-Office to buy up all the telegraph systems of the various telegraph companies of this country who were willing to sell their property. This all have been found willing to do, and meetings have been held authorizing the directors to agree to the Post-Office terms, which have been usually a twenty years' purchase on present rates. The final amount to be paid to the various telegraph companies has to be settled by arbitration. Agreements have also been entered into between the Postmaster-General and the various railway companies, by the which it is settled that all wires belonging to the railway company, and used by them for their special services of train signalling or otherwise, shall remain theirs, in addition to which the railway company will in future maintain all wires, poles, and telegraphs, the property of the Government, passing over their lines. Under this arrangement, there may be perceived the following curious change—what the telegraph companies formerly did and still do for the railway companies the railway companies will now do for the Government.

The Post-Office are making great internal changes preparatory to taking charge of the telegraph system, and to complete the transfer it is now only necessary to bring into Parliament the bill for providing the necessary funds. It is anticipated that this will be done very early in the year, and by July 1 it is most probable that the various telegraph companies will have handed their systems over to the Government.—*Mechanics' Magazine.*

THE HEATON PROCESS.—The discussion on the merits of this process, still occupies many dreary pages in the London newspapers. Nothing very new or important has been elicited. We shall, in a future number, give a very brief abstract of the situation up to date.

THE MOLDAU SUSPENSION BRIDGE AT PRAGUE.

The peculiarity of this bridge is that there is only one pier, or tower, and that is in the center of the river, so that the bridge is really formed of only two half spans, each half being in the clear 305 feet six inches, the thickness of pier being eighteen feet at the crown. The distance from face to face of abutments is 629 feet; on each shore there is no room for the anchorage chains, &c., to extend such a distance inland as would be required if towers were used instead of abutments. And it was considered advisable to have only one pier or tower in the river, to avoid as much as possible intercepting the ice.

The particulars of the work are thus given in "Engineering": The bridge is for foot passengers only, and has a clear width of eleven feet from end to end. Each column of the pier being built clear of this width involves the chains being wider apart, in plan, in the center of the bridge than at the abutments; this arrangement gives the structure considerable resistance to any side motion that might be caused by the wind.

The abutments and anchorages are built of stone, with concrete fillings. The pier in the center of the river is also of stone from its base to the underside of the superstructure, where the ornamental cast-iron tower commences. The tower consists of two pillars or columns connected at the top by an open cast-iron girder, and each column consists of four standards firmly connected together and bolted at their bases to the pier. The height of the bridge above the highest level of water is six feet six inches, and height of tower from same level is 63 feet.

The chains are of steel, and formed of links in 21 feet lengths by four and a half inches deep by one inch thick, having heads and eyes, and steel pins of three and a half inches diameter. The main chains have each six links in width, and they are connected to straight chains which pass direct to the base of the tower. These straight chains are applied to prevent as much as possible the rising or moving of the curved chains when an unequal load is passing over the bridge. The straight chains have only two links each of the same dimensions as the links of the curved or main chains. The main chains are supported on the tower on a saddle resting upon seven cast-iron rollers, each three feet long and four and a half inches diameter, and carefully turned, from whence they pass to the abutments, where they rest on other saddles, and from thence they pass to their anchorage. The anchorage for each end of each main chain consists of seven steel plates resting upon two cast-iron girders or bed plates, the four bed plates being connected together by cast-iron girders. The connections for the adjustment of the lengths of the main chains are near the tower and in the abutments, and for the straight chains at the base of the tower, and can be adjusted by means of steel gibs and keys.

The footway or platform is formed of two main longitudinal parapet girders in one continuous length from end to end of bridge, and rests upon cast-iron cross girders twenty-one feet apart, which are suspended by wrought-iron suspension rods one and a half inch. diameter, to the main chains. The main or parapet girders are one foot six inches deep, the top and bottom flanges being formed each of two pieces of pine, having a total sectional area of 72 square inches. The diagonals are also of pine, six inches by three inches, fitted into cast-iron shoes cast on the ends of the C I verticals; these have a wrought-iron bolt one inch diameter passing through them, firmly connecting the bracing to the flanges. The verticals aro seven feet apart, and at these distances there are cross timbers acting as girders to support the planks of the footway, so that there are two timber beams and one cast-iron girder in every 21 feet to carry the planking of the footway. The planking is four inches thick, and on this is boarding one and half inch. thick, laid crosswise. The footway, besides being suspended to the chains, is also connected to the base of the tower by means of four diagonal rods, which allow it to move only vertically to a slight extent, but not horizontally.

The quantity of cast iron contained in the tower saddles, anchorage girders, cross girders, verticals in parapet girders, &c., is 108 tons. The steel in the chains, plates and pins is 78 tons, and four tons of wrought iron in bolts, &c. There are 5,600 cubic feet of timber work in the platform.

The bridge will have to stand a test moving load of 96 pounds per square foot, and will not give a greater strain on the steel chains than twelve tons per square inch, and the breaking strain of the steel is 36 tons per square inch. The links are being made at the Cyclops Steel and Ironworks, Sheffield, and the other work is being made at Prague. The pier and anchorage and abutments are now complete, and the anchorage chains are in place. It is to be opened for traffic on the 1st of November of this year.

The design was made by Mr. R. M. Ordish, and is being executed by the same contractors who had built the Franz Joseph Bridge, viz., Messrs. Ruston & Co., Prague. Charles Von Wesseley is the resident engineer. The contract for the structure has been taken for £18,500.

THE METAL HYDROGEN.

Based on its chemical and physical properties, the opinion has long been held that hydrogen is a metallic element. Though only known to us in the form of a gas which has hitherto resisted all our endeavors, by pressure and cooling, to cause it to change its state of aggregation, and condense to a liquid or take a solid form, it cannot fail to be recognized that its existence in this condition only, depending as it does on the imperfection of our scientific instruments, in nowise invalidates the doctrine of its metallic nature. The attempts to condense hydrogen were unsuccessful on account of the difficulty of rendering vessels absolutely tight at such enormous pressures. Mercury, on the other hand, is liquid at ordinary temperatures; zinc, magnesium, and other metals are readily converted into gas, and gold and silver can be volatilised in the electric arc. Platinum, which Faraday melted in the flame of a candle, can doubtless be dissipated as vapor. The failure, therefore, to solidify hydrogen at present proves nothing.

The difficulty of condensing hydrogen has recently been attacked from another direction. About a year ago the Master of the Mint startled the scientific world with the announcement that he had extracted hydrogen from iron.

He placed a piece of the Lenarto meteorite in vacuo, and on subjecting it to heat drew from this iron several times its volume of hydrogen. This gas which, when free, so readily diffuses that it cannot be preserved for many days in a tube over mercury, but passes between the mercury and the walls of the tube and escapes into the air, was so firmly combined with the iron that, not the removal of atmospheric pressure alone, but the application of heat also, was required to effect their separation.

Recently Mr. Graham communicated to the Royal Society another paper on this interesting subject. He now employs a metal that absorbs hydrogen, as melted silver or platinum black does oxygen, or water ammonia. Palladium occludes from eight to nine hundred times its volume of hydrogen, and he regards the product as an alloy of palladium with the volatile metal hydrogen, in which the volatile character of the one metal is restrained by its chemical affinity for the other, but which owes its metallic characters to both. The alloy has a density considerable less than that of palladium, and he has been enabled to calculate that of the metal hydrogen, which he finds to be 1·951. Hydrogenium, as the new alloy is called, is more magnetic than palladium, in the ratio of 48 deg. to 10 deg., and must be considered to forsake "the class of paramagnetic metals, to take a place in the magnetic group of iron, nickel, cobalt and others." The occlusion of hydrogen by palladium reduces its tenacity and electric conducting power.

The strongly marked magnetic character of hydrogen, the readiness with which it forms alloys of such great permanence, and, more especially, its occurrence in combination with iron in meteoric masses, are facts of special interest at the present time, now that the spectroscope has revealed the existence of such enormous quantities of this element in our system.—*The Engineer.*

THE STRENGTH OF CORRUGATED IRON.

As a supplement to Mr. J. H. E. Hart's paper on this subject,* we publish the following letter by him to the "Bombay Builder":

Sir—Referring to experiments on the strength and stiffness of corrugated iron, published in your journal August, 1868, I have to suggest to your readers the following formula for the deflection of the material, obtained from equations in Professor Rankine's work. At page 328, article 303, of the third edition of "Applied Mechanics," is the general equation—

$$\sqrt{\frac{\prime}{1}}=\frac{n''M'_0c^2}{E\,I_0} \quad . \; . \; . \; . \; . \; . \quad (25)$$

for the "deflection of a beam under any load," in inches. In this formula $c = l$, or $\frac{l}{2}$, according as the beam is fixed at one end only, being unsupported at the other, or supported at both. Confining ourselves to the case of sheets supported at both ends, the above equation becomes—

* Van Nostrand's Magazine, Vol. I, No. 2, p. 129.

$$\surd'_1 = \frac{n'' M'_0 l^2}{4 E I_0} \;.\;.\;.\;.\;.\;.\; (26)$$

The values of M'_0 are those already given for M in equations 10 and 11, at page 95 of Vol. IV. of this journal; n'' is a factor depending on the distribution of the load, and is, for beams loaded in the middle $= \frac{1}{3}$, and for beams loaded uniformly $= \frac{5}{12}$.

E is the modulus of elasticity of wrought iron in pounds; I_0, the moment of inertia of the cross section of the beam. We may, I think, adopt the value of I_0 for the cross section of corrugated sheets obtained from the equations for the transverse strength of the material. The general equation for the moment of resistance of a beam (see "Applied Mechanics," article 294) is $\frac{f I^o}{Y}$, and the value of $y = m' h$; also, as for all symmetrical sections $m' = \frac{1}{2}$, therefore $Y = \frac{H}{2}$ whence the moment of resistance $= \frac{2 f I_0}{H}$

But, as already mentioned, the moment of resistance (see "Civil Engineering," page 543) for corrugated sheets is $\frac{4}{15} f\,h\,b\,t$, and this equals $\frac{2 f I_0}{H}$, whence

$$I_0 = \frac{2}{15} h^2\,b\,t. \;.\;.\;.\;.\;.\; (27)$$

and equation 26 becomes for corrugated iron generally

$$\surd'_1 = \frac{15\,n''\,M'_0\,l^2}{8\,E\,h^2 b\,t}. \;.\;.\;.\; (28)$$

and for the following particular cases:—

SHEETS SUPPORTED AT ENDS.

For central loads, $\surd'_1 = \frac{W\,l^3}{6{\cdot}4\,E\,h^2\,b\,t}$. (29)

For distributed loads. . . . $\surd'_1 = \frac{W\,l^3}{10{\cdot}24\,E\,h^2\,b\,t}$. (30)

E, the modulus of elasticity, may be deduced from the experiments under reference by the formula

$$E = \frac{W\,l^3}{6{\cdot}4 \surd_1 h^2\,b\,t}. \;.\;.\;.\; (31)$$

which, using the data obtained, gives values for E ranging from 21,000,000 to 30,000,000, being, on the average, 25,000,000; or it may be taken from any of the published results on the elasticity of wrought iron. Thus, in Professor Rankine's work we find E = 29,000,000 for bar iron; also E = 24,000,000 as a "good average" for plates. For the case of sheets fixed at both ends the deflection is (article 307, "Applied Mechanics")—

$$\surd'_1 = \left(n'' - \frac{m''}{2}\right) \frac{M_0\,c^2}{E\,I_0}. \;.\;.\; (32)$$

In this formula $m'' = \frac{1}{2}$ or $\frac{2}{3}$, according as the load is collected in the center or uniformly distributed; and in both cases the value of $n'' - \frac{m''}{2} = \frac{1}{12}$, also c^2 as before $= \frac{l^2}{4}$ and as the case may be; therefore equation 32 becomes,

IN SHEETS FIXED AT ENDS.

For central loads—

$$\surd'_1 \frac{W\,l^3}{192\,E\,I_0} = \frac{W\,l^3}{25{\cdot}6\,E\,h^2\,b\,t}. \;.\; (33)$$

For uniformly distributed loads—

$$\surd'_1 \frac{}{384\,E\,I_0}\;\frac{W\,h^3}{51{\cdot}2\,E\,h^2\,b\,t}. \;.\; (34)$$

Hence, it appears, sheets are made stiffer by fixing their ends, in the ratio 4 : 1 for central loads and 5 : 1 for uniformly distributed loads. We see from previous equations that they are made stronger in the ratio 2 : 1 and $1\frac{1}{2}$ to 1 respectively.

In calculating values of E from the experiments, it is advisable to reject the first weight and its deflection, basing the calculations on the difference between the first weight and deflections and those of a value of somewhere about one-third the breaking weight. The reason for this precaution is that any error due to the first settling of the sheets to their bearings may be eliminated from the result.

SAFETY OF STEAMSHIPS.—A correspondent of the London "Times" proposes to clear steamers of water entering by leakage or shipped in heavy weather, by means of steam jets arranged something like the Giffard injector, and worked with the full boiler power, if necessary, so as to discharge, say, 1,000 cubic yards of water per minute. It certainly seems unnecessary for a ship with 1,000 to 5,000 horse power, all in working condition, to founder for the want of means of application. The jet proposed would be simple and always ready to work. Centrifugal pumps would, perhaps, accomplish more, keep the ship afloat with a bigger hole in her, and might be kept always in order.

THE HERCULES IRON-CLAD.

REMARKABLE PERFORMANCE — PARTICULARS OF THE ENGINES, THE VESSEL AND THE TRIAL.

Compiled from "Engineering" and "The Engineer."

The attainment by an iron-clad frigate, at her deep-load draught, of a speed of 14.7 knots, or over seventeen miles per hour; and the development of 8,528 indicated horse power by a pair of marine engines weighing with their boilers, water, etc., complete, but 1,095 tons, are facts, the importance of which it is impossible to overrate. These results were obtained on January 1st, by the Hercules, and are extremely creditable to her designer, Mr. E. J. Reed, and especially so to Messrs. Penn, constructors of her engines.

Description of the Vessel.—The Hercules is the latest, and the representative broadside ship of the British navy, and is of the following dimensions:

	ft.	in.
Length	325	0
Breadth	59	0
Draught forward	23	0
Draught aft	26	5
Tonnage	5,234 tons.	
Displacement	8,680 tons.	
Midship section	1,315 sqr. ft.	

Her armor consists of a belt of plating, extending from five feet below the water line to nine feet above it, this belt being surmounted by the central battery, whilst at the stem and stern are the armor-clad batteries in which the fore and aft guns are placed. At the water line the armor consists of nine inch plates, backed by 40 inch. of teak, whilst above this belt the thickness of the plates is reduced to eight inch. and six inch. The ends of the central battery are protected by six inch plates. The armament comprises eight eighteen ton guns, throwing 800 pound shot, placed in the central battery; a twelve ton gun, throwing 250 pound shot, mounted under the forecastle behind armor-clad ports; a similar gun, mounted in the captain's cabin, in an armor-clad stern battery; and four six and a half ton guns, throwing 115 pound shot, placed on the upper deck, and fought through unarmored ports. Of the eight eighteen ton guns, four can be fought through the ordinary side ports, the sills of which are eleven feet above the water line, whilst the other four can be fought from ports at the angles of the central battery, and can be fired within fifteen degrees of the centre line of the vessel. The twelve ton guns can be fired directly in the line of the keel, the one forward, and the other aft, whilst they have each also a considerable lateral range. Besides possessing a most powerful armament, the Hercules has been so constructed that she may be used for ramming purposes, and for such a method of attack her great handiness and high speed peculiarly fit her.

Description of Engines.—These are trunk engines, by John Penn & Son. They are fitted with surface condensers, exposing 20,768 square feet of surface, the condensing water being supplied by a pair of centrifugal pumps, arranged so that they can be made to draw from the bilge, and capable of delivering 120 tons of water per minute. The circulating pumps are driven by a pair of independent engines.

Steam is supplied by eight boilers, having 40 furnaces, the fire-grate surface being 907 square feet, and the total heating surface 23,100 square feet, of which 19,792 square feet are tube surface. The boilers are fitted with eight superheaters, containing, in all, 3,908 square feet of surface.

Number of cylinders	2
Diameter of cylinders	127 in.
Diameter of trunks	47 in.
Effective diameter of cylinder	118 in.
Stroke	4 ft. 6 in.
Nominal horse power	1,200 H. P.
Load on safety valves	30 lb. per sq. in.

Temperature of steam in superheater from 305° to 310°.

Propeller.	Description	Griffiths' varying pitch from 20 ft. 6 in. to 25 ft. 6 in.
	Diameter	23 ft. 6 in.
	Pitch	24 ft.
	Length	4 ft. 7 in. at root of blade, 1 ft. 3 in. at periphery of do.
	Immersion of upper edge	1 ft. 11½ in.

Of the machinery of the Hercules, and of its performance, it is impossible for us to speak too highly. As specimens of excellent design, combined with the very best workmanship which even Messrs. Penn can produce—and their workmanship is certainly unsurpassed, and in but very few cases equalled—the engines of the Hercules stand unrivalled, whilst the power developed by them by very far exceeds that ever obtained on shipboard from any engines, under any circumstances whatever. Mr. Penn has long taken the lead in the adoption of high speeds of piston, and the success he has obtained has decisively shown the advantages of such speeds, when accompanied, as they should be, by first-class workmanship.

The Performance.—The trial at Stokes Bay, on January 1, consisted of six runs over the measured mile, under full steam, and four runs under half-boiler power, under the conditions of craft mentioned above, and with the following particulars of power, speed, etc.:

	Full power.	Half power.
Pressure of steam in boilers	29. 5 lb.	21.87 lb.
Vacuum in condensers — for'd.	27.08 in.	28. 5 in.
Vacuum in condensers — aft	27.08 in.	28 in.
Number of revolutions — max'm	72.00	58.52
Number of revolutions — mean	71.51	55.29
Mean pressure in cylinders	20.00 lb.	12.268 lb.
Indicated horse power	8,528.75	4,044.91
Speed of vessel	14.691 knots.	12.122 knots.
Time under way	5 hrs. 25 min.	
Time at full speed without stopping	1 hr. 55 min.	
Weather barometer	30.20 in.	
Wind — Force	2 to 4	
Wind — Direction	S.W.	
State of sea	Smooth.	

Engines stopped from time of moving telegraph .... 19 sec.
Engines started ahead from time of moving from astern .... 14 sec.
Engines started astern from time of moving telegraph .... 16 sec.
State of masts, yards, etc. .... complete.
Quantity of coals on board .... 600 tons, including 70 tons of trial coal.
Armament .... complete.
Quantity of stores .... six months'.

	No. of runs.	Revolutions of engines per min.	Observed time.	Speed due to time.	First mean speeds.	Second mean speeds.
				knots.	knots.	knots.
Full power.	1	71.51	3.47	15.859	14.621	....
	2	70 93	4.29	13.383	14.763	14.692
	3	71.31	3.43	16.143	14.617	14.690
	4	72.00	4.35	13.091	14.764	14.690
	5	71.78	3.39	16.438	14.624	14.694
	6	71.53	4.41	12.811	....	....
		71.51	Mean.	True mean speed.		14.691
Half power.	1	58.42	4.27	13.483	12.394	....
	2	55.51	5.21	11.215	12.036	12.192
	3	54.00	4.40	12.857	12.071	12.053
	4	53.23	5.19	11.285	....	....
		55.29	Mean.	True mean speed.		12.122

The engines exerted rather more than seven times the nominal power. The importance of this fact will be brought into a stronger light by comparing the engine power and displacement of the Warrior, Bellerophon and Minotaur with those of the Hercules. In the official reports we find the following results:

WARRIOR.

Nominal H. P.	1,250
Indicated H. P.	5,092
Displacement in tons	9,214
Pitch of screw	30 ft.
Revolutions of screw	52.6

MINOTAUR.

Nominal H. P.	1,350
Indicated H. P.	6,193
Displacement in tons	10,275
Pitch of screw	25 ft.
Revolutions of screw	54.96

BELLEROPHON.

Nominal H. P.	1,000
Indicated H. P.	6,199
Displacement	7,369
Pitch of screw	20 ft. 1 in.
Revolutions of screw	73

HERCULES.

Nominal H. P.	1,200
Indicated H. P.	8,500
Displacement	8,610
Pitch of screw	24 ft.
Revolutions of screw	71.5

It will be seen from these figures that the Warrior has one horse power to every 1.8 tons of displacement nearly; the Minotaur has one horse power to 1.64 tons nearly; the Bellerophon has one horse power to 1.72 tons, and the Hercules one horse power to 1.01 tons nearly. To this vast excess of power is due the fact that the Hercules is faster than her larger rivals. Calculating from these data the co-efficients according to the usual formulæ, we get:

	Full boiler power.	Half boiler power.
$\frac{\text{Speed}^3 \times \text{mid sec.}}{\text{Ind. H. P.}} =$	488	578
$\frac{\text{Speed}^3 \times \text{disp.}^{\frac{2}{3}}}{\text{Ind. H. P.}} =$	157	186

It is difficult to compare the constants of the Hercules at her full speed with those of other ships, for no other iron-clad has yet steamed so fast at deep-load draught, and, as is well known, the increased speed obtained under such circumstances must be accompanied by a reduction of the constants. The half-power runs seem to show clearly that, for a short ship, her form is very good, as her half-power constants are higher than the Bellerophon's. The respective half-power constants are as follows:

Hercules.	Bellerophon. (at load draught)
578	543
186	171

the speed of the Bellerophon being, then, 12.154 knots, or almost exactly that of the Hercules under similar circumstances. The full-power constants of the Hercules fall below those of the Bellerophon, which vessel gave, on different occasions, when tried at load draught, the following constants: 518 and 163, 534 and 167, and 530 and 166. Considering, however, that, as we have already mentioned, the constants fall with an increase of speed—and especially at very high speeds—the Hercules has given very good results, as the Bellerophon constants just given were obtained with speeds of 14.171 knots, 13.874 knots and 14.023 knots respectively, whilst the speed of the Hercules was, as we have seen, 14.691 knots. It must not be forgotten, however, that as the Hercules stows but 600 tons of coal, she cannot keep the sea at full speed for any time. Six hundred tons of coal are as nothing in comparison with 8,000 horse power or so. The consumption of fuel cannot be much less than fourteen tons per hour. Therefore, in round numbers, the Hercules carries coal enough to steam at full speed for forty-three hours only, or to carry her, assuming her to have a fourteen-knot sea speed, 602 knots only. In this respect she possesses the worst defects of the short iron-clad.

It is important to observe that the weight of the engines complete and of the boilers and water, is but 1,090 tons, or two and a half cwt. per indicated horse power, a weight which is wonderfully small under any circumstances, and particularly so when the size of the engines is considered. The proportions of areas of the heating surfaces, fire-grate surface, &c., to the power developed, are as follows:—

	Per indicated horse power.	
Heating surface	2.7	sq. feet.
Fire-grate "	0 106	"
Superheater "	0.47	"
Condensing "	2.43	"

As to the handiness of the vessel, we have the following particulars. The balanced rudder first used on the monitors by Captain Ericsson, is employed.

Circles made Under Full Power.—Helm to starboard,—Angle of rudder, 40 deg.; turns of wheel, four. Half circle made in one min. 50 sec.; full ditto, four min. Men at the wheel, sixteen. Helm to port.—Angle of rudder, 38 deg.; turns of wheel, four. Half circle made in one min. 50 sec.; full ditto four min. Men at the wheel, sixteen. The diameter of the circle made in each instance was estimated at not more than twice and a half the ship's length.

Circles Under Half Boiler Power.—Helm to starboard.—Angle of rudder, 40 deg.; turns of wheel, four. Half circle made in two min. 21 sec.; full ditto, four min. 36 sec. Men at the wheel, sixteen. Helm to port.—Angle of rudder, 39 deg.; turns of wheel, four. Half circle made in two min. 40 sec.: full ditto, four min. 50 sec. Men at the wheel, sixteen.

Conclusions.—The British authorities conclude that no other navy in existence can boast of the possession of a ship at once so fast, so handy, so impregnable, so strong, or carrying so heavy an armament. The impregnability, the strength, the handiness, and the powerful armament of the ship are due to Mr. Reed, and he may well be satisfied with the honor which this fact does his reputation as a shipbuilder. But the great speed of the ship is due to Mr. John Penn, and it is only by the adoption of a high piston speed that such results could be obtained; and to such speeds, when combined with good design and workmanship, there is no objection whatever. All the expectations formed respecting her have been more than surpassed in the performance of her engines. The builders had counted upon a speed of 65 revolutions, and an indicated power six times the nominal, but so far were the results beyond these, that the engines averaged 71.51 revolutions, or 643.6 feet of piston per minute, and exerted 7.107 times their nominal power, or 8528.75 indicated, giving one indicated horse power to every 2.7 square feet of heating surface, a proportion seldom exceeded even in locomotive practice, with its quick draught and consequently rapid rate of combustion. Of course we are to admit that the runs were not of very long continuance, the coals were hand picked, and fired with little regard to economy, and the heating surfaces were clean. The indicator cards show not far from 25 lb. of water, or 0.4 cubic foot, for each indicated horse power at full speed, or about 3,411 cubic feet in all, being one cubic foot to about 6.77 square feet of surface, a high rate in marine practice, although often exceeded in locomotives. There are some forms of marine boilers—those, for instance, with water tubes—which show, according to Mr. Isherwood's experiments, but one cubic foot of evaporation for every 30 square feet of heating surface, the latter being in the case of the Merrimack, 12,537 square feet, while the steam discharged per hour into the condenser, the steam having been calculated from the indicator cards alone, was equal to but $403\frac{1}{2}$ cubic feet. It is true that this was fourteen years ago, but the same class of boilers is still employed in the American navy.

Steel Rails.—Over 11,000 tons of steel rails are now in use on the Hudson River Railway.

RAILWAYS FOR CHINA.

From "Engineering."

Now that a through communication across the American continent, by means of the Pacific railway, is nearly completed, with a direct route to the chief Chinese ports, a fresh interest has been awakened as to engineering prospect in the Celestial Empire, and engineers are turning their attention so far eastward.

The principles upon which a railway system in China is established, must differ very widely from those which have governed the formation of lines in other new countries. For instance, in India there was a responsible government; throughout it were plentifully scattered the necessary elements for carrying out the undertaking—English energy and enterprise. Even less then than now, was the country burdened with official routine and red-tapeism. Shareholders were liberally guaranteed, and the rapid construction of railways were as necessary for military purposes as for the development of the country's natural resources. Preliminarily, there was only English opposition to conquer—no native prejudices to overcome.

In China, an entirely different moral aspect rules. From Imperial Majesty downwards, jealousy of foreign interference must take the place of hearty co-operation, and Imperial Celestial guarantees would scarcely satisfy capitalists who have had sore experience of European repudiation. The vital military necessity for rapid communication from one part of the country to another is not fully understood; and there exists the difficulty of overcoming national prejudices, which the effacing of the footsteps trodden by a hundred generations must inspire. The insecurity of Government guarantees, the jealousy of Imperial officials, and the prejudices of the people, are there, the principal difficulties to be encountered.

On the other hand, China possesses a vast undeveloped mineral wealth, and the monotonous industry of her 367,000,000, now put forth year by year, for the preservation of life, not for advancement; for the most part, the well-cultivated alluvial territories are level, and on these tracts the vast mass of the population is found, where labor is so cheap and abundant, and where the essentials for railway construction are most easily attainable. The enormous traffic now floated slowly and laboriously down the canals and rivers to the commercial centers would be transferred to the more rapid and cheaper mode of conveyance, and the introduction of railways would be followed by an invasion of western energy to the almost unworked fields which have been closed to the outer world for so many thousands of years.

The British residents in China agree with those missionaries, whose experience is invaluable, that the first experimental line should be made between Canton and Fatshan, a manufacturing town lying fifteen miles to the south of the larger city, and containing paper factories, gun foundries, and other industrial works; at present some half a million passengers are conveyed between the two places by passage boats, and the transit of merchandise is regular and heavy; this line could be completed in fifteen months. Far away to the north, another experimental line could well be made from Tientsin, the terminus of the grand canal, to Pekin, 70 miles distant, a railway which would secure all the traffic from the canal to the capital, and bring the advantages of a railway system under the immediate notice of the Imperial Government.

In sketching out his views as to the most favorable course for the trunk lines of China, Sir Macdonald Stephenson (who proposed a plan of railways for China in 1846) takes the town of Hankow, on the Yangtse-Kiang, as a commercial center, from which the railways would run east to Shanghai for 650 miles, south to Canton and Hong Kong for 850 miles, and north to Pekin for 800; westward the distance to India is 1600 miles. Shorter lines would connect Canton with Samshui, 40 miles distant, and would intercept the traffic now brought down the north and west rivers, at the junction of which Canton is situated. Between Hong-Kong and Canton, an extensive passenger traffic would be obtained by the construction of 90 miles of line. At present, passage boats and four American steamers meet the requirements of trade. Shanghai and Luchow are two important cities between which exists an enormous traffic that could be secured by the laying of 60 miles of railway through a level country. The line from Hankow to Canton, in passing through the Mieling range of hills, where the only engineering difficulties occur, would strike through extensive coal fields, 60 miles north of Canton, and now worked only rudely, and near the surface.

This large and promising field for engineering will not lie much longer fallow. Anglo-Saxon enterprise will soon be at work in it, and it is reasonable to hope that native opposition will soon give way after the first railroad is opened.

THE LAKE CONSTANCE RAILWAY FERRY.

Compiled from "Engineering."

This ferry, for the transportation of merchandise trains, will connect the town of Friedrichshafen on the northeastern, with Romanshorn on the southwestern side of the lake, the distance across being about eight miles. Friedrichshafen is the terminal station of the Royal Wurtemburg States' railway, leading from Ulm, Stutgard and Frankfort. Romanshorn is the terminus of the Swiss Central railway, which runs to Zurich, Lucerne, Berne and Lausanne.

The vessel, which is constructed to carry twelve wagons, is 230 feet long on the railway deck, 40 feet beam, and six feet six inches deep from the top of the floor to the underside of the beams of the railway deck. Her tonnage is 1,753 tons, builders' measurement, and her draught of water does not exceed six feet. The hull of the vessel, together with the deck, deck houses, paddle boxes, paddle beams, and upper works generally, are of iron; and there is also an iron upper deck 80 feet long, placed at a height of about fourteen feet above the railway deck, so that it is clear of the carriages. The railway deck is provided with two lines of rails six feet apart, each line being capable of accommodating six wagons. The form of the vessel is the same at both ends, each end being fitted with a rudder provided with suitable stops. For a length of 100 feet amidships the vessel has a parallel body, and this part is built on the longitudinal principle, the framing consisting of longitudinal stringers two feet wide, with single angle-irons at top and bottom, and transverse frames two feet wide at the bottom and sides, and eighteen inches at the top, with single angle irons at the outer and inner edges. These latter frames are placed eight feet apart, except at the engine rooms, where they are spaced to suit the engines. The ends of the vessel beyond the parallel body are also built upon the longitudinal system as far as possible, but the extreme ends have frames of the usual kind. The outside plating of the hull is one-half inch, and the inside plating three-eighths inch thick, whilst the angle-irons are throughout three and one-half inches by three and one-half inches by one-half inch.

The vessel is divided by transverse bulkheads into nine water-tight compartments, the central compartment being thirty-two feet long, whilst six others are each twenty-four feet long, leaving the end compartments to make up the remainder of the length. In the central compartment are placed the engines, as we shall explain presently, while in the two next compartments, one forward and one aft of it, are situated the boilers and coal bunkers. Besides the transverse bulkheads there are two longitudinal bulkheads, which are placed twenty-two feet apart, and which extend the whole distance between the extreme transverse bulkheads. The railway deck is made of plates planed at the edges and butt jointed, and it is carried by transverse beams eighteen inches deep, and placed eight feet apart, these beams being firmly rivetted to the skin, and being each supported at the center by a hollow wrought-iron column fixed to the floor plates. Four longitudinal beams, eighteen inches deep, also assist in stiffening the railway deck, these beams being placed immediately beneath the lines of rails.

The engines are of 200 horse power nominal, and consist of two independent pairs arranged one on each side of the vessel, in the spaces which are divided from the central part of the longitudinal bulkheads. Each pair of engines consists of two oscillating cylinders inclined so as to form an angle of 90 degrees with each other, these cylinders being three feet four inches in diameter with six feet stroke. The centers of the cylinders are in line, the two piston rods being coupled to one crank pin. The engines are fitted with the link motion for reversing, and are also provided with separate expansion gear. The cranks are overhung, there being one frame in each engine-room supported by a pair of columns, while the outer ends of the shafts are carried by the paddle beams. The paddle wheels are twenty-four feet in diameter, and have each twenty-four fixed floats; and as each wheel its driven by its independent pair of engines the two wheels can be run in opposite directions to facilitate turning the vessel if required.

In the space between the two pairs of engines is placed an auxiliary engine which drives one of Gwynne's centrifugal pumps, and also the four capstans of the ship. There are four boilers, two to each pair of engines, and they are placed close to the sides of the vessel, the one pair forward and and the other pair aft of the engines to which they respectively belong. The coal bunkers are also placed close to the sides of the vessel, the one forward and the other aft of the engines, each bunker being thus on the opposite side of the ship to the boiler which it supplies. By the arrangement of boilers above described, the funnels are brought to the sides of the vessel clear of the railway trains. The boilers are worked at a pressure of twenty-eight pounds per square inch.

As the water level in Lake Constance varies somewhat at different seasons, and as the vessel is of course liable to fluctuations of load, it may be required on some occasions to lower either end of the vessel to facilitate the embarkation or debarkation of the wagons. For this purpose the compartments between the two extreme bulkheads at each end are not only made watertight but are well stayed, so that they serve as water holds. Cocks and pipes connected with the pumps driven by the auxiliary engine enable these compartments to be filled with water and emptied at pleasure; and by filling one of them more or less, the end of the vessel to which it belongs can be sunk as required.

The designs and specifications for the ferry boat we have described, were prepared by Mr. J. Scott Russell, who is the engineer to the undertaking. The boat and engines were built by Messrs. Escher, Wyss & Co., of Zurich, the engines being designed by Mr. Murray Jackson, who was at the time manager to the above mentioned firm, but who is now engineer-in-chief to the Danube Imperial and Royal Steam Navigation Company. From some delay which has occurred, the ferry has not yet commenced running, but it is expected to start soon, and there is no doubt that it will be a success.

HEAVY RAILS.—The plan of Mr. Brunlees, for the new railway from London to Brighton (although it is to be a "cheap" railway, involves the use of steel rails of over 100 lb. to the yard, so as to have a head of the width of the tread of the wheels, and to distribute the weight of the rolling stock so as to obtain less than the present weight per wheel, and thus preserve the way.

TRACTION ENGINES IN FRANCE.

RESULTS OF EXPERIMENTS — THE ENGINES IN THE EXPOSITION. BY MONS. D. SIENARD.

Translated from "Annales du Génie Civil."

The problem of steam traction on common roads has been considered for a long time, even before the invention of railways; but not until within a few years has it begun to receive a practical solution. The road locomotive seems naturally called to fill the interval necessarily left in our system of railways; and it also offers important resources to certain industries which, like the beet sugar manufacture in particular, require much local transportation. It is, therefore, a question wholly practical; and although I am not prepared to treat it fully, I think it will be interesting to state the result of experiments which I have had occasion to follow up in the department de l'Aisne, on two road locomotives, the one of English manufacture, the other from the works of Mons. Albaret of Liancourt.

Mons. Albaret, in the arrangement of his machine, has not departed widely from the type of the railway locomotive. The boiler is composed of a cylindrical fire-box, and a horizontal barrel traversed by tubes, and is fed by a Giffard injector; and the heating surface is about 172 square feet. As the engine is to go on steep grades, it was necessary to provide against the inconveniences of changes in the water level. This difficulty has been happily solved. The horizontal barrel is full of water; and the steam formed in it while going up hill is received in a small dome on the forward end, and carried thence by an exterior pipe to the main dome over the fire-box; and the crown-sheet of the fire-box, instead of being flat, is hemispherical, and therefore always covered by an equal depth of water, whatever the inclination of the road.

The motive apparatus is composed of two cylinders, with link-valve gear placed under the boiler, and protected from dust by sheet-iron coverings, easily removed for oiling and cleaning. The crank-shaft transmits the motion by gearing to an intermediate shaft close in front of the fire-box, and on a level with the driving axle; and from this shaft the power is transmitted by an endless chain to the axle which is behind the fire-box. The driving wheels can be loosened or fixed to the axle by bolts, but not without stopping the engine. I do not know whether others have, in a practical manner, fastened and loosened the wheels while in motion; but this is one of the points which ought to have the attention of mechanicians. The machine cannot turn conveniently without one wheel loose; and so long as the fixing and loosing cannot be effected while in motion, it will be almost necessary to work with one wheel loose, thus using only half the force which the machine might exert.

Road locomotives not being guided by rails, it is necessary that their front axles should be turned to the right or left. It is in this part that they differ most from each other. In the arrangement of Mons. Albaret, the front axle wheels are in advance of the smoke-box. To the middle of the axle is jointed an upright spindle, which turns in a socket that is held by a prolongation of the upper part of the smoke-box—the prolongation being high enough to allow the wheels 54 inches high, to turn under it, like the wheels of a common coach. The spindle is worked by an endless screw turned by a hand crank, gearing into a worm wheel on the upper end of the spindle. The shaft of the screw is prolonged to the foot-plate, so that the engineman can steer; and in this respect it has an advantage over other engines, which require special men to steer. This arrangement is important; because, independently of the saving of the wages of a steersman, it renders the maneuvering much more easy and certain. The machine is mounted on springs to soften the effects of jarring and jolting. In front there is a conical spiral spring around the spindle; and the hind springs are of the common laminated kind. The total weight is about ten tons, of which six and a half are on the drivers, which are five feet high and fourteen inches wide at the rims. The usual speed is five kilometres an hour, and the highest speed allowed is seven kilometres, (about three and one-third and four and one-third miles).

After being exhibited at the competition at Laon, in 1866, this engine was bought by Mons. Godin-Lemaire, to draw coal and iron for his foundry at Guise (Aisne). It worked between Guise and the fort of Longchamps a distance of four kilometres (two and two-third miles). It went out lightly loaded, and returned with a useful load of 15,000 kilogrammes (about fifteen tons), and burns at the maximum 250 kilos (550 lbs.), of coal per round trip. At these rates the daily expenses are less than half the cost of horse power.

Mons. Godin-Lemaire is, nevertheless, little satisfied with the results of his experiment—for it is not enough that the current expenses be reduced; it is necessary moreover that the machine shall be exempt from frequent derangements and important repairs. Unfortunately this locomotive leaves something to be desired in this respect. In the first place there have been and still occur, numerous leaks at the tube joints. These may be due to bad original construction; but it is to be feared that the suspension of the boiler is not without influence in this evil. The boiler is suspended at its ends, the axles nearly fourteen feet apart, and the jolts may cause strains very prejudicial to the joints. In the second place, the endless chains that transmit the power from the intermediate shaft to the driving axle have been found too weak; and the links and the teeth of the pinions have been much worn, and there have been many ruptures of them. Moreover the chains have been elongated—and not being sufficiently guided they have sometimes got outside the teeth, under the effects of violent lurches. Attempts have been made to mitigate the effects of the lengthening of the chain, by applying a tension rod, and making the pillow blocks of the intermediate shaft adjustable; but it is clear that the most efficacious remedy would be in the use of a chain so strong that the elongation would be insignificant; for, in spite of the two expedients above stated, there was produced such a difference between the relative pitch of the chain and the wheels, that they could not work together without a series of small shocks.

However these points may be, Mons. Godin-Lemaire seems convinced that the transmission by chain is, in itself, bad; and that the road locomotive cannot become really practicable and capable of regular service, until the chain is superseded. I do not know whether the future will confirm this opinion; but I will remark that the experiments have been made under disadvantages, as Mons. Godin-Lemaire himself was the first to point out. In fact, the Longchamps route, which leads also to Bohain, is the one on which is performed nearly all the traffic of the industrial establishments of Guise. It is extremely worn, even to such extent that the merchandise brought from the north by railway has to be loaded at St. Quentin instead of Bohain. From this fact it will be understood that the route is very ill prepared to receive the road locomotive; that the machine was exposed to numerous chances of accident which it would not have met in ordinary practice; and that we cannot accept as definite the condemnation of a system, on the results of an experiment made under such unfavorable conditions.

The other experiment, of which I shall now speak, has given more satisfactory results. Mr. Pilter, an English mechanician, instead of copying the railway locomotive, has limited himself to adopting an ordinary portable engine, and establishing a connection between the crank-shaft and the driving axle, by means of an intermediate shaft and an endless chain, as in the French engine. The engine is placed on the boiler; the fly-wheel is retained; and by ungearing the intermediate shaft, the locomotive may be made to work as a portable engine. It is therefore particularly convenient for agriculturists. The boiler is a plain cylinder and fire-box, without dome, and has 203 feet of heating surface. No special precaution has been taken to prevent changes of the water level on hills; and only a fusible plug is put in the crown-sheet, to cause the fire to be extinguished by a jet of steam in case the crown-sheet should become dry and hot. It is fed by a pump which can be worked while the engine is standing, by ungearing the intermediate shaft. The driving-wheels are 64 inches in diameter, and sixteen inches width of rim. As in Albaret's engine, they are fastened and loosened by bolts; but in the French machine the fastening is possible in any position in which the engine can stop; while in the English it is necessary to bring the wheels to one position on the axle, so that the holes may be in line. The front swivelling train is very complex. It has three wheels; the hind axle under the fire-box, held to it by a swiveling joint. The steersman sits with his back to the smoke-box, and by a tiller turns the front wheel as it is turned in toy carriages. The system works perfectly in forward motion; but in maneuvering and in untrained hands there is likely to be a misunderstanding between the engineman and the steersman which may involve much loss of time, if not more serious consequences. The total weight, and the distribution of it on the axles, is about the same as in the French engine—and the ordinary speed is the same, three and one-third miles an hour.

This is the engine which, in October, '67, made the experiments of towing boats on the Oise, of which all the journals have spoken. It was thence taken to the sugar manufactory at Braisners, near Soissons, where Mons. Duffié proposed to use it for the transportation of beets. It worked for about 40 days between the factory and a depot at Cuiry-Housse, eight kilometres distant. The road is in very good condition, but its profile was very accidental, for it has barely two kilometres of level, and the rest is in steep hills and inclines varying from three to seven in 100. Its ordinary train was two large wagons, each containing 7.4 tons of beets. On the return trip it drew five to six tons of pulp. It made two round trips per day, and burnt 1,540 to 1,760 lbs. of coal. In going and returning the tank was filled with water by means of hose from a pond six kilometres from the factory; and in addition, to provide for emergencies, the train was always followed by a cask on a cart containing from two to three hectolitres of water. In dry weather the traction was easy, but in wet and muddy weather there was such slipping as to show the necessity of lightening the loads or roughening the wheels. Notwithstanding the regulations against rough wheels, the administration, fôr the sake of rendering the experiment conclusive in all respects, made no opposition, and Mons. Duffié applied on the tires of the driving wheels strips of plate iron 1.2 inches wide by 0.4 inches thick and 24 inches apart (eight on the entire circumference). With this addition the machine drew its load over the hills, and was no farther hindered in its work until the time of ice and fresh snow.

The service of this machine was generally satisfactory during the winter of 1867–8. This is not to say that it always avoided accidents, and that there were no ameliorations to be desired. Far from it. As the fusible plug corroded, it had to be replaced every week, although it had never been left completely uncovered. The chain, though stronger than that of Albaret, has had several links broken, and at the end of the season it had to be replaced. There have been some ruptures of teeth; and, at the outset, before the men had become expert, the complication of the swivelling train or three-wheel bogie occasioned some accidents during its maneuvers, such as getting into the ditches of the road, from which the machine could not always extricate itself. But these are accidents inevitable in the beginning of a new system, and Mons. Duffié, recognizing that his apparatus is far from having attained its ultimate perfection, does not hesitate to regard this machine, even in its present state, as capable of practical use, and of rendering important service to industry.

We will say a few words about cost.

Mons. Duffié generally sent four men with his convoy—three on the engine and one behind to look out for the train and hold the horses that were met, and aid the measurers at the beet depot. The wages of these men was 13 francs per day. The coal cost 21 francs (at 28 fr. per ton), and the oil cost four francs. In all, 38 francs per day to transport 40 tons of beets or pulp eight kilometres. The cost of haulage therefore amounted to .119 fr. per ton per kilometre. As to the general expenses, they are difficult to estimate, for they depend on the number of days of work in the year and the importance of the repairs of the machine. Mons. Duffié hopes to use the engine 100 days in the year, 50 in winter for transporting beets, and 50 in summer for supplying coal and for working in cultivation. The engine cost 14,000 francs, and six wagons at 1,000 francs each, makes 20,000 francs for the cost of his material. Allowing 20 per cent for interest and decay, the engine being estimated to last six years, and adding 1,000 francs per year for repairs, we have a yearly expense of 5,000 francs, which distributed over the work of the 100 days gives .156 francs per ton per kilometre. The total cost, therefore, is .275 francs. At this rate, Mons. Duffié has already realized some economy, for the transport of beets by the wagoners has never cost him less than .3 francs, and it has often cost more in unfavorable seasons.

These costs have been very largely estimated, and in many cases they may be much reduced. The consumption of coal has been enormous, nearly 24 kilogrammes per kilometre, which is just twice what the constructors state in their advertisements, but without reckoning the lighting of the fires. This excess arises from two causes. First, from the profile of the road, whose grades considerably augment the resistance to traction. Second, the season in which the work was done, for the resistance to rolling varies much in consequence of the dryness or wetness of the road. When the road was frozen they have been able to make three round trips in a day, and then the consumption of coal did not exceed 950 kilogrammes; that is, less than 20 kilogrammes per kilometre. We may therefore admit that in a fine season, and on a route with good grades, the consumption would not exceed sixteen or eighteen kilogrammes, and the price would then be lowered .02 per ton per kilometre. Besides, I have supposed only 100 days' work in a year, while the machine could easily work 250 days and leave time enough for cleaning and repairs. Computing in this case the decay at 30 per cent and the repairs at 1,500 francs, the general cost would be lessened at least one franc per ton per kilometre. Finally, Mons. Duffié's engine worked but 32 kilometres daily, when it could have worked 40 or more, and, in effect, it did but a third of the work of which it was capable. I think, then, that it may be concluded, from the experiments at Braisne, that in the present state of the engines they can transport at .2 francs per ton per kilometre, provided they have work enough to keep them fully employed, and to attain this result it will suffice to have 400 tons of transportation to do during 250 days in the year. This amount of work could, at the most, supply a railway only two kilometres long.

In what precedes I have occupied myself only with the machines. I have endeavored to show the results already attained and to indicate the improvements which had to be realized. I cannot pretend to have succeeded fully, since I have had occasion to examine only two types of road engine, both exclusively for freight. But in the organization of a system of steam traction it is necessary also to think of the embarrassment of the travel already existing on the roads and of the effect of the new system on the preservation of the roads. In these relations the experiments at Guise and Braisne are conclusive. The locomotive obeys with the greatest docility the direction of its conductor, and easily makes way for other vehicles to pass; but, owing to its great weight, it does not always do this without danger to itself, when the roads are narrow and the sidings are very soft. In such case it cannot always cede half the road, as required by regulations, without difficulty to itself. Horses soon accustom themselves to the noise of the machine, and after a few trips they pass without more alarm than they show in passing common vehicles. Still, with pleasure horses that are more spirited than work horses, precautions are taken; but these horses are not frequently met.

Finally, the locomotives, with their broad wheels, heavily loaded, serve as road rollers, and seem to have only good effects on macadam. The front wheels being nearer together than the drivers, a considerable part of the road is rolled and there is no tendency to form ruts. At Guise, as at Braisne, it was remarked that the road was injured only by the wagons, whose wheels were not wide in proportion to their loads. It will be easy to build wagons with wider wheels and the front wheels nearer together than the hind wheels as in the locomotives, so that the steam trains may have the best effect on roads.

By the regulations made for road locomotives, their tires must be smooth, without any projection. It was feared that if otherwise, they might break up the surface and seriously impair the durability of roads. But the trial of Mons. Duffié showed that these fears were unfounded. I was at Brisne after several days of rain. On the road there were some parts dry, others moist and soft, and others covered with mud. On the dry parts the holding strips left slight traces; on the soft parts there were mere impressions of the strips; and only in the mud, where the foot would leave a track, was there any tearing up; and this did not extend below the stratum of mud nor affect the macadamising. And even this slightly injurious effect would not have been produced had the strips been put near together, instead of two feet apart. With this distance apart it often happened that no strip had held, and there was slipping, and the next strip arrived at considerable speed, striking a blow which tore up the ground. Yet at the end of the year this road was not more worn than at the end of previous years, and Mons. Duffié had no increased road taxes to pay. And I am persuaded that the interdiction of holding strips will be removed, since they are allowed in England, where road engines have come much into use. I will add that, in my opinion, this is a condition indispensable to the general use of steam traction, for the load that can be drawn with smooth tires is too limited, the force of the machine not well utilised, the dead weight too considerable, and the transportation cannot be performed with full economy. And were it true, which I think is not, that the projecting strips injured the roads, their use should nevertheless be permitted; for the State and the Departments, in providing for the repairs, would only have to lay just taxes on the new engines, which they could pay, and still work with advantage.

The Exhibition of '67 in the Champ de Mars brought together nine road locomotives, from four French and five English construetors. The English seem not to have thought seriously of applying them to the transportation of passengers, for their machines are adapted to draw heavy loads at relatively low speed—seven or eight kilometres at most. But in France the inventors have schemed to carry both passeners and goods. The locomotive of Mons. Larmanjat can draw only three tons, but its speed is sixteen to eighteen kilometres per hour, which is practicable only for passengers. Mons. Lotz, of Nantes, has aimed to construct a machine suitable for both services. The other French constructors, like the English, propose to carry only merchandise.

Before examining each machine particularly, I will glance at the whole together, to set forth the general characteristics adopted by their constructors.

Boilers.—Besides the conditions common to all boilers, there are two specially necessary to be considered in boilers for road locomotives. First, they must be made so that the fire-box crown-sheets shall remain covered with water while going up hills. Second, the form of the boiler should permit a firm and accessible arrangement of the organs of motion. The English have all adopted the same kind of boiler—the locomotive without a steam dome. This allows great latitude in the arrangement of the engines, on top or underneath. The danger of burning the crown-sheet is guarded against by a fusible plug, which will melt and allow steam to extinguish the fire before an explosion can occur. This system is simple, but it cuts the knot rather than unties it, and it may have the inconvenience of supplying moist steam, for want of a high and copious reservoir.

The French have been more inventive. The design of Mons. Albaret we have described. That of Mons. Larmanjat is analogous to it. Mons. Calla's has also a dome over the fire-box and a barrel long enough to accommodate the motive mechanism. But the most radical solution is given by Mons. Lotz, who completely separates the boiler from the engines. The boiler is upright and behind the driving axle, and the engine is inverted and attached to the tank, which is placed forward at the distance suitable for the gearing and chain. The two conditions which I have stated are perfectly fulfilled, but it is to be feared that the boiler will be found too small for the speed proposed. On the whole, I think the English type is really the most practical.

MOTIVE MECHANISM.—The first question is, whether there should be one or two cylinders. With two the motion is more equable, and there are no dead points. With one the construction is cheaper, and the maximum effort greater. This last advantage is not to be disdained in a machine which is liable to get mired, and to require for a moment a strong exertion of force. On this question opinions are divided, and of the nine engines, four (three of which are French), have two cylinders. The English have all put their cylinders on top of the boiler, near the chimney. Calla has put his cylinders on top, but near the fire-box. Albaret and Larmanjat place theirs under the boiler, where the mechanism is least accessible and most exposed to dust; but they have endeavored to exclude dust by coverings. And Lotz has placed his cylinder vertically over its shaft, in the forward part of the vehicle. This disposition is perhaps objectionable on account of the disturbance by the up-and-down movement of the piston.

MODE OF TRANSMISSION OF THE MOTION.—I have already spoken of the inconveniences of chains for transmitting motion from the intermediate shaft to the driving-wheels. Nevertheless, there are but three English constructors who have completely abandoned that system. Whatever be the mode of transmission, nearly all the machines can vary the number of turns of the engine to one turn of the wheels. Those of Albaret and Pilter are the exceptions. The others, excepting Lotz and Larmanjat, who aim to carry passengers, in their devices to vary the speed, have no other object than to save time when going without loads. All the French engines are on springs, and this is evidently advantageous on account of durability; but none of the English have deemed it useful to adopt this refinement. All the French engines have smooth driving-wheels, as required by the regulations. The English restrict themselves to this condition only in engines which they hope to sell in France.

STEERING APPARATUS.—For the swivelling of the front axle or truck there are as many plans as there are constructors. Of the nine machines five are steered by a special conductor placed in front; the four others are steered by the engineman. In going forward the first system evidently gives most safety; and it appears to me best for passenger carriages; but it is more costly, and renders maneuvering more complex, in consequence of want of perfect understanding between the engineman and steersman. I now pass to the examination of the different models separately, commencing with the English.

PILTER'S ENGINE.—Having shown the general arrangement of this machine, I shall here consider only some details of construction. The intermediate shaft, between the crank-shaft and the driving axle, is not placed high enough to pass over the top of the boiler; it therefore has but one bearing, and its working end overhangs. This disposition is unsatisfactory, and it is not surprising that several ruptures of the pillow-block occurred on the machine belonging to Mons. Duffié. On Pilter's locomotive, in the Exhibition, the motion is transmitted by wheels with conical surfaces, which work against each other, depending on friction. This system has the advantage of easy connection and disconnection while in motion; but it may be questioned whether, in practice, this kind of frictional gearing will have sufficient adhesion.

AVELING & PORTER'S MACHINE.—This has the same disposition as that of Pilter's, which is but a copy of it; for Aveling invented the three-wheel truck.* The intermediate shaft is not over-hung, as in Pilter's, but is placed high enough to pass over the boiler, and have a bearing each side. This shaft and the crank-shaft carry gear wheels at both ends, with different proportions, so that the speed may be varied by throwing either the right or left into gear. As in Mons. Duffié's machine, the fixing of the wheels is by bolts. Experience proves that when the tires are smooth, the fixing can be effected very well while in motion When one wheel is fixed and the other loose, the former slips a little, and soon brings the holes into line, so that the bolt can be pushed home; and this happens the sooner when the slipping is greatest, and there is

* We translate without comment. Our readers may know that this is older than Aveling; and on other points they may see that we might have corrected the author; but we deem it best to reserve our criticisms until we have occasion to write an original article on this subject.

most need of the adhesion of both wheels. The loosening is not practicable without stopping, for the bolt is held too strongly to be withdrawn while the power is exerted upon it. Porter's steering gear certainly requires the least effort of the steersman of any that I have seen. In maneuvering it requires a certain degree of expertness; but even in this view it is not inferior to the other systems that require a special steersman. Messrs. Aveling & Porter had two locomotives in the Exhibition, for which they received a medal. One, of six horse power, was bought by Mons. Schotman, of Don, to tow boats on canals. The other was of twelve horse power. They have engines now at work at the sugar factories in Nesles (Somme), in Barbiere (Oise), and in Moncornet (Aisne).

Machine of Clayton, Shuttleworth & Co. (Medal of the Exhibition)—It has two cylinders under the boiler. The transmission of the motion is by spur-gearing on two intermediate shafts; one of them over-hanging, like Pilter's. They say, in their prospectus, that their engine can turn curves of the shortest radius, being enabled by differential gearing of their own invention. I could not see this mechanism, as the attendant of their machine covered it when he saw that I was studying it closely. It has two steering wheels and a steersman in front.

Ransome's Machine.—This has one cylinder on the boiler near the chimney. The motion is transmitted by spur-gearing on two intermediate shafts, one of which is used only for slow motion. The fixing of the wheels is by friction clutches; but it is not effected while in motion. It has two steering wheels, and the smoke-box rests on the centre of the axle. Chains go from the ends of the axle to a horizontal wheel behind the engineman, who steers.

Underhill's Machine.—This has one cylinder. The motion is transmitted by spur-gearing. The fixing of the wheels is by bolts, as in Pilter's. It has two steering-wheels, with the load on the middle of the axle, as in Ransome's. A strong rod, jointed to one end of the axle, goes to the foot plate, where it is formed into a rack, and pushed or pulled by a pinion worked by the engineman. What strikes us in this machine is the extraordinary form of the driving-wheels, whose rims are of wood, with iron tires zigzagged, so as to leave on the ground a track similar to one represented by the figure 6. This system may give adhesion; but it may be feared that it will fail to give strength. For the rest, the constructors seem to have aimed to make portable engines that could propel themselves from place to place, rather than traction engines, for they have not provided coal boxes.

Larmanjat's Machine. (Medal of the Exhibition.)—It is of three horse-power, and expressly for passengers, and can draw three tons. Its centre of gravity is very low, which gives it great stability. It has two cylinders under the smoke-box turning a crank-shaft under the fire-box. This shaft acts by gearing on the driving axle. Behind the driving axle is a shorter axle, with smaller wheels, and an endless chain transmits the motion from one axle to the other. By levers, worked by screws, the smaller wheels may be made to carry the load, or may be lifted clear of the ground,—the wheels that are not carrying continuing to turn. When on a level the large wheels carry and run at sixteen to eighteen kilometres an hour; and on hills the small wheels carry at seven to eight kilometres. The higher speed is ten to eleven and a quarter, and the lower is four and three-eights to five miles per hour. This combination seems capable of working well; but evidently it is inapplicable to a heavy engine, and could not be used for a locomotive that draws heavy loads. It is steered by one wheel, held by a forked spindle, on the top of which is an arm, to which is jointed a rod worked by a pinion, by the engineman.

Lotz's Machine.—In external appearance this machine differs entirely from the others, which all more or less resemble railway locomotives or portable engines. In this all the organs are placed on a sheet-iron body with three wheels. Behind the driving axle is an upright boiler, and in front is the engine. The cylinder is vertical. The crank-shaft and two intermediate shafts are on a level with the platform. The motion is transmitted to the drivers by an endless chain. Gearings of different proportions, with clutches, enable the machine to be worked at three rates of speed. This complete separation of the boiler from the machinery has the great advantage of rendering repairs easy; and the engineman has all parts in sight and accessible. But, as I have said, the boiler appears too small. The driving axle has springs and axle boxes like those on railways. The fixing of the wheels is by a brake, analogous to that in Ransome's. The axle of the steering wheel is fixed in a horizontal wheel with teeth on its rim, into which a pinion works, and a special steersman works the pinion. Lotz's engine has been bought by the director of the glass-works of Folembray (Aisne), and has worked since November, 1867, between Coucy and Chauny, transporting materials and products. Several other similar machines work at Orleans and at the mines of Blanzy.

ALBARET'S MACHINE.—Save, in a few details, Albaret's machine in the Exhibition is like the one we have reported. The endless chains are made stronger; and this is the only one that has a chain to each driving wheel.

COLLA'S MACHINE.—It has a framing like a locomotive, formed of two long plates with proper connections. This is an improvement; for it bears the shocks and strains which in the English and Albaret's engines are thrown upon the boiler. It has a steam dome over the fire-box, and a barrel long enough to receive the engines. The cylinders are on top, near the fire-box, and the crank shaft forward, and the intermediate shaft further forward, close to the chimney. With this arrangement the endless chain has to be very long, though the driving axle is before the fire-box; and the lengthening of the chain must therefore be more sensible. There are two steering wheels in front of the smoke-box, under the frame plates. The axle is connected to a horizontal wheel with a toothed rim, into which a pinion gears; and the pinion is turned by a band wheel worked by a special steersman. The drivers are fixed and loosened by clutches, which are worked while the engine is in motion. In the other engines the steersman in front has only to steer. In this he has to work the clutches which fix the wheels, and also to work the levers which change the rates of speed. The engineman has charge of the throttle, the reversing lever and the fire. Experience only can show whether this division of functions, between men so far apart, is the most advantageous. Under the seat of the conductor is a shaft worked by a chain, which in case of accident will serve to warp the machine forward, by winding a chain or rope that is fastened to an anchor or other fixed object ahead. This engine is solidly built; all its parts have been well studied; and all the difficulties have been noticed. But there is another side: on account of the steam dome the boiler has been made long to give room for the mechanism. The necessary organs are numerous, and augment the weight; and as the division of the weight between the axles is very unequal, because of the driving axle being before the fire-box, the weight on the drivers is excessive, twelve tons at least. This weight far exceeds the regulations; and there are few routes on which such a heavy engine could work safely.

I conclude this rapid review by saying that I entirely agree with the international jury who awarded the first premium to Messrs. Aveling & Porter. Their machine is the one which, by its simplicity and good construction, seems for the present to offer the best assurance of efficient and regular service on common roads.

ENGINEERING IN INDIA.—From a comprehensive article in the Calcutta "Engineers' Journal," we learn that the Government has fully sanctioned the establishment of the best schemes of irrigation and navigation throughout this vast industrial empire. Among the schemes for irrigation, surveyed and to be commenced, are the construction of 16 reservoirs in the Midnapore district, from which some 75,000 acres of land may be watered; also a canal for navigation and irrigation, from the Damoodah to Calcutta, 100 miles (already commenced); a system of canals from the Gunduck for the benefit of the districts of Chumparan, Sarun, and Tirhoot, and a canal from the Ganges at Rajmahal to Calcutta, also the Sutlej canal in Punjab—all these canals being designed to prevent the horrors of famine heretofore prevalent, and being adapted to navigation.

An Imperial sanitary commission has been appointed. One of its chief duties is to detect the cause of disease as arising from drainage, water supply, and ventilation. Simultaneously with this office the Government of India has made the appointment of an experienced mining engineer in connection with the geological survey of India, for the purpose of determining with precision the mineral resources of India, improving and extending mining operations, and subsequently collecting and tabulating the mineral statistics of the country, which has been looked upon with great pleasure and satisfaction by the country at large.

THE "UNIVERSAL" ROLLING MILL.

In an article on the progress of the British iron trade, "The Engineer" says: There is no one practically connected with the iron trade who is not tolerably familiar with what, by the use of the universal mill, Messrs. Petin, Gaudet & Co., for example (in France), have been able to accomplish. Their famous rolled beam 39⅜ inches in depth, exceeding 32 feet, in length, and weighing two and a half tons, with also their more than two-ton beam, upwards of a foot in height, and above 106 feet in length, in the Paris Exposition, evidenced the capabilities of the the universal mill.

The mill, as laid down at Messrs. Petin, Gaudet & Co.'s works, is not remarkable for novelty, for its essential features are to be found elsewhere, and Mr. Abram S. Hewett claims that they were embraced in the first train for rolling beams erected in 1853 at the Trenton works, New Jersey. Whilst the universal mill is by no means unknown to many of our readers, they may nevertheless feel interested in reading the description of it as given by the intelligent American ironmaster and United States commissioner we have named. He says that "for each size of beam there is a pair of rolls, each having a working face at the middle of its length equal in width to the depth of the beam. The diameter of the roll at this part is very large, say three feet six inches, the body of the roll for the rest of its length being about 22 inches in diameter. This formation of the rolls leaves a considerable space between the two, except where the working faces come together. In this open space is placed a pair of rollers working on vertical axes fixed in stout movable frames, by which they can be brought into juxtaposition with that portion of the horizontal rolls which is of largest diameter. The pile used is somewhat thinner than the width of the flange to be produced, and of a width somewhat greater than the depth of the beam, and is so made up as to conform roughly to the final shape of the girder. As the main rolls are brought together and form the trough in the beam, the friction rollers at the sides are also pressed towards the centre, and tend by the pressure which they exert to extend the flanges at the same time that the web is being drawn out by the main rolls. An offset is turned in the side of the large portion of the rolls to receive and form properly the flange as it is extended by the pressure of the friction rolls. The latter are worked each by a screw in a horizontal frame bolted to the side of the housing, the screw being provided with a ratchet lever to be worked by hand. This enables the thickness of the flanges to be adjusted with precision. With this mill Messrs. Petin, Gaudet & Co. have rolled girders of 40 inch high, 33 feet long, and feel confident they could make them 90 feet in length." We have said that the essential features of this mill were applied in the United States, more than fifteen years ago, but in the mill at Trenton the axes of the driver rolls and of the friction rolls were at right angles to the mill of Petin, Gaudet & Co. That the latter is a better working arrangement than the former there can scarcely be any doubt.

It is no argument against the universal mill that the immense products exhibited in Paris as resulting from its operation are mere *tours de force*. No doubt a careful observation of the various structures in process of erection on the continent would fail show that these remarkable specimens of rolling have yet been brought within such limits of cost as to admit of their use in building. We know that in the Exposition building itself, no rolled beams were to be found of a greater depth than nine inches; and it is a fact that in the very many structures which are now being put up in the capital of France in which iron beams are invariably employed to the exclusion of wood, four-inch, six-inch and seven-inch are the dimensions most generally employed. But now that it has been found possible to produce beams of such large dimensions by the simple process of rolling, Mr. Hewett himself observes, "it is but reasonable to expect that the cost will be reduced as experience is gained, and that the large single girders will gradually replace the riveted girders, which even in the palace of the Louvre are invariably employed for spans of any considerable extent."

The universal mill had its origin in this country, but it came out at a time when its importance was not correctly estimated here; nor, so far as it relates to beams of the class we have been writing about, would its application have been of much value in England at this time. Now the mill is getting into use. The most recent train of this kind is intended for rolling long narrow plates without the necessity of their being afterwards sheared.

STRESS DIAGRAMS FOR STRAIGHT RAFTER ROOFS.

In a former article* we explained how the stresses in a Warren girder can be determined by means of a simple and easily constructed diagram. We will now proceed to determine the stresses in some of the commoner kinds of iron roofs—such as are indicated in figs. 1 and 3. In the form most commonly used in England, fig. 1 represents a roof with four bays to each half. The first step is to determine the load which produces the most unfavorable stresses in the different bars. In general, this load is not the same for all the bars; but in the present case, in which the top and bottom beams A C and A J are straight and meet at the end points A and B, the greatest load possible uniformly distributed over the whole rafter gives the greatest stresses in all the bars. We have, therefore, to consider this load only. It consists, first, in the dead weight of the girder; second, the weight of the covering; third, in the greatest possible load of snow which may fall on the roof; fourth, the maximum pressure of the wind. The girder ought to be loaded at the connecting points only—that is to say, at the points A D E F C, &c., for otherwise the bars of the top beam would have to sustain bending forces requiring more material than for mere tension or compression. We, therefore, suppose that the covering rests on the girder only at these points. When one of these points, E, for instance, is loaded with the weight upon half the bay D E and upon half the bay E F, or when the top beam is divided into equal portions, the load upon one connecting point is equal to the load upon a rectangular superficies extending in length from one rafter to another, and extending in breadth from one connecting point of this rafter to the next. The weight resting upon the points A and B does not affect the construction, as these are directly taken up by the support. Let us now suppose the weight on each connecting point to be two tons. Then the whole load on the girder is 7 by 2, or 14 tons. As this is symmetrically distributed with regard to the two supports A and B, each of these has to take 7 tons. These data are sufficient to determine the stresses, and we will begin to construct the diagram of forces.

We employ in this instance a mode of denoting the bars and forces which is much more convenient than that used in the former article. Structures to which the graphical method is applicable consist of bars forming a number of triangles, and we accordingly write in each of these triangles a figure, successively numbering these triangles in their natural order. In figs. 1 and 3, this is done by the numerals 5, 6, 7, 8, 9, 10 and 11. Opposite each top and bottom bar other figures are placed, and it will be observed that for all the bottom bars the figure 0 is used, whilst the bars in the top plane have different numerals, 1 2 3 4. This difference is due to the fact that the bottom is not loaded. If one of the connecting points at the bottom—for instance the point C in fig. 1—were loaded, we should be obliged to use, to the right and left of the load at C, different numerals. In this way each bar has at each of its sides a figure by which it is clearly indicated. The top bar, E F in fig. 1, is thus denoted by 2 8, whilst 6 7 denotes the bar E G. Similarly the load at point E may be denoted by 2 3. This mode of marking the bars will, perhaps, appear at first rather strange and arbitrary; but we shall see further on that it greatly simplifies the indication of the forces in the diagram of stresses and the correspondence between the two figures.

The process of constructing the diagram of forces for this roof is exactly the same as in the former case of a Warren girder. We begin at the point A, where the known resistance of the support acts with a force of 7 tons. This we have to decompose into two components with the directions of the bars 4 5 and 5 0. Draw a line 0 4 (in fig. 2) parallel to the force A in fig. 1, and therefore vertical, make its length to any scale, equal to A, or, in our case, equal to 7 tons. Through the two end points 0 and 4 draw lines parallel to the directions of the bars 0 5 4 5, and let these lines meet at the point 5. Then 0 5 and 4 5 in fig. 2, determine the forces respectively acting in these bars. To ascertain if these forces produce tension or compression we follow round the triangle 0 4 5 in the direction which is prescribed by the direction of the known force 0 4. We find that the force 4 5 acts from 5 to 4 and 0 5 from 0 to 5. In the girder, fig. 1, these forces act parallel; the force in 4 5 acts parallel to the direction from 5 to 4; or from D towards A in fig. 1. It, therefore, produces compression; similarly, the force in 0 5 acts in the direction from 0 to 5 in fig. 2; that is, from A to C in fig. 1, pro-

*See Van Nostrand's Magazine, Vol. I, No. 1, p. 13.

FIG. 1.

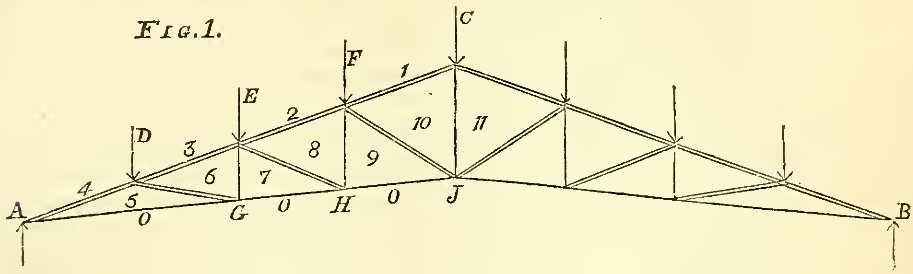


FIG. 2.

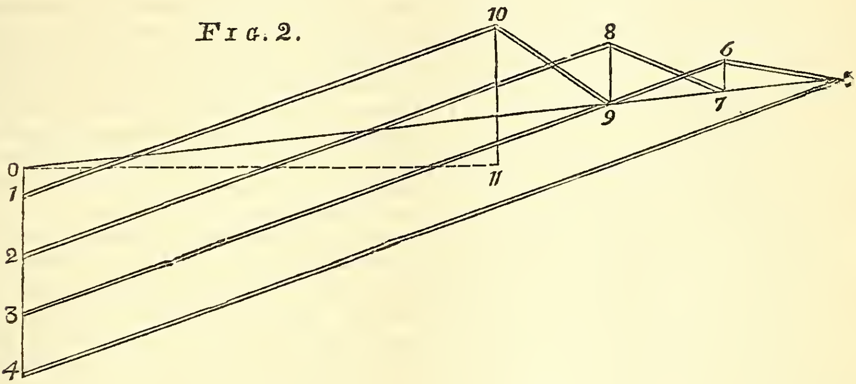


FIG. 3.

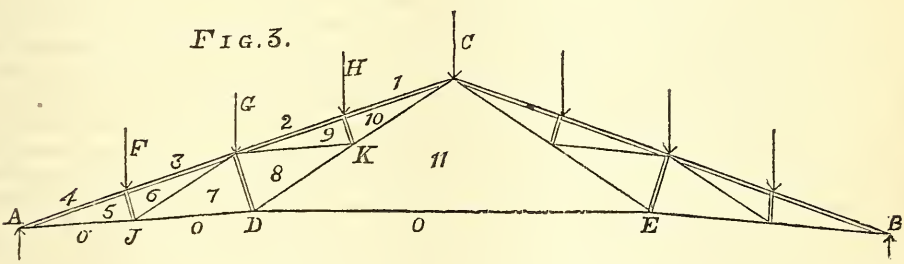
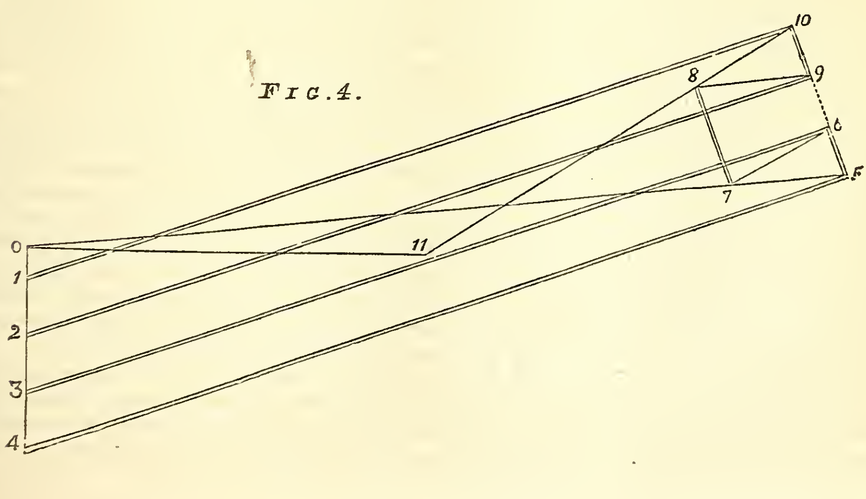


FIG. 4.



ducing tension. Compression is again denoted by a double line in both figures. We now go to the point D, where we have to combine 4 5 with the load 3 4 of two tons; and to decompose the resultant into the directions of 5 6 and 3 6. We remember that the compressed bar 4 5 presses at the point D in the direction from A to D; or, in this diagram of stresses, in the direction from 4 to 5. To this force 4 5 we add the load 3 4. The line adjoining 3 5 would give the resultant of the two known forces acting upon the point D. It is unnecessary to draw this line. We decompose this force with the given directions by drawing through the end and points 3 and 5 two lines parallel to our two bars 5 6 and 6 3 in fig. 1. Let 3 6 and 5 6 be these lines, which intersect at 6. Then 3 6 in fig. 2 is the stress acting on the bar 3 6 in fig. 1; and 5 6 that acting upon the bars 5 6. To find the direction of these forces we follow round the polygon 3 4 5 6 in the direction determined by the known forces 3 4 and 4 and 5, which are, as required, placed together in such wise that they travel the same direction by passing along these lines from 3 over 4 to 5. Proceeding, we pass from 5 to 6, and from 6 to 3. Hence the force 5 6 has in fig. 1 the direction G to D. It presses against the point D, and has, therefore, to sustain compression; and 3 6 has likewise compression. We next come to the point G, where 5 0 and 5 6 act as known stresses. They are represented in the diagram of stresses by the lines having the same figures and placed in the same way as they point in the direction 0 5 6. Drawing through the end points 6 and 0 lines parallel to the bars 6 7 and 7 0, we get the lines 6 7 and 7 0 as stresses in these two bars. They act in the direction from 7 to 6 and from 0 to 7; or in fig. 1 in the direction from G to E and from G to H, as we follow round the lines in the direction 6 5 0 7 6 0. Hence both bars are undergoing tension. In this case, the line 0 7 coincides in direction with 0 5, but by our present mode of notation an ambiguity is impossible. We thus continue, necessarily taking the points E H F J. Drawing from each point the corresponding lines in the diagram of stresses we obtain fig. 2.

This diagram determines all the stresses. Measuring all the lines with the same scale by which the first line 0 4 is made equal to 7 tons, we obtain the stresses directly. Only the stress 10 11 in the center tie-rod is not given at its proper amount. The line given in the diagram represents the tension down to only one-half of the rafter; but as this bar belongs equally to the second half, the stress, as taken from the diagram, is to be doubled.

Here, as in the case of a Warren girder, we have determined all stresses by expressing for each connecting point that the forces acting upon that point are in equilibrium. We began at one of the supports and proceeded by taking the other connecting points in their natural order till all the stresses were found. This process is always possible, unless it should happen that these forces are unknown at one point. This is not the case with the rafter, fig. 3, which illustrates a form of roofing much used in France and Belgium, and known in England under the name of the French roof. A diagram as simple as that in the former case enables one to determine all the stresses.

We again suppose the rafter, fig. 3, to be loaded at the connecting points F G H C, and so on for the other half, and with equal weights—say 2 tons at each point. The whole load will be 14 tons, half of which comes upon each support. This load of 7 tons we represent by the vertical line 0 4 in fig. 4, and divide it at the points 1 2 3 in such wise that 4 3, 3 2, 2 1, each represent 2 tons, corresponding to the loads at the points F G H. The remaining part 1 0 is then equal to half the load at C. Through the points 4 3 2 1 draw lines parallel to the top beam A C, and through 0 draw a line 0 5 parallel to the bottom beam A D, which cuts the lowest of the former lines at 5. Through this point 5 draw a line 5 10 parallel to the struts 5 6, 7 8, 9, 10, or at right angles to 4 5. This line determines the points 6 9 10, and the forces in the top beam by the lines 4 5, 3 6, 2 9 and 1 10. Lines drawn through 0 and 10 parallel to D E and D C meet at 11, and determine the stresses 0 11 in the great tie rod D E, and in the bar 10 11. To complete the diagram it only remains to draw 9 8 and 6 7 parallel to the corresponding bars in the elevation, fig. 3, and to join 7 8. Having done this, all stresses are determined, and the figures at once show which line in the diagram represents the stress in any bar in fig. 3. Double lines represent compression, and single lines tension.

The correctness of this diagram has now to be proved. Beginning, as before, at the support A we easily see that 4 5 and 0 5 are the two forces. Knowing these, we determine the next ones, which meet at the points F and J. Here we stop; for if we proceed to the point G the *three* forces 7 8, 8 9 and 9 2, are unknown; and if we try to take the point D first, then again three forces have to be determined, namely, 7 8, 8 11 and 11 0. The diagram is, indeed, found by a somewhat differing method; but it being once given it is easy to be seen that it must be correct, for it gives stresses which are in equilibrium at each connecting point. The forces, for instance, acting upon the point G are given by the figures placed round G, namely, by 3 6 7 8 9 2 3. These figures, in fig. 4, are the angular points of a polygon of forces, and, as this is closed, we have equilibrium at G. Similarly for all other points. By following such a polygon round in the direction determined by any of its forces, we further ascertain which bars undergo compression and which have tension. In the polygon for the point G, for instance, the load G or 2 3 acts in fig. 4 in the known direction from 2 to 3. Hence, following round in the direction 2 3 6 7, &c., we see 3 6 acts from 3 to 6, and parallel in the elevation, or towards the point G. Thus 3 6 undergoes compression, aud so on for the others.

These diagrams show very strikingly how the stresses alter with the inclinations of the top and bottom beams. Suppose, for instance, we make the top beam in fig. 1 more inclined, then the line 4 5 in the diagram of forces will turn round the point towards the line 4 0. The point 5 then moves towards 0 in 0 5, whereby the lines 4 5 and 5 0 are rapidly shortened; and similarly with all the other lines in the diagram. Hence all the forces decrease by giving the top beam a greater incline, or by increasing the depths of the rafter.

The above is from the "Building News." The same subject is treated by James H. Cotterill, M. A., in "Engineering," under the following title:

On the Graphic Construction of Bending Moments.—It has long been known that the ordinates of a funicular polygon, corresponding to a system of parallel forces in one plane, represent the bending moments produced on a beam by the action of those forces; at least, such a principle has been employed in special problems, though, perhaps, never distinctly laid down as a general property of the funicular polygon. For instance, it must have struck every one who has considered this subject that the curve representing the bending moment at any point of an uniformly loaded beam is identical with the curve in which a chain hangs under a load, which, like that of a suspension bridge platform, is uniformly distributed horizontally. Also, it is not difficult to perceive that the multiplier by which the numerical value of the bending moment is obtained is the horizontal tension of the supposed suspension chain.

The remarkable construction now to be explained is founded on this property of the funicular polygon, and, as it appears to be very little known, I have thought that a short notice might interest the readers of this journal. It is, so far as I know, due to Prof. Culman, of Zurich; and I am acquainted with but one other writer who uses it, namely, Prof. Reuleaux, in his valuable work "Der Constructeur" (Note 1).

In Culman's work (Note 2) the properties of the funicular polygon are very thoroughly investigated, and a whole system of applied mechanics founded thereon; but the construction for bending moments, which appear to me to be of considerable value, may shortly be demonstrated thus: "Take, for

FIG. 3.

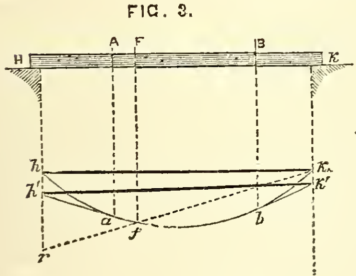


FIG. 1.

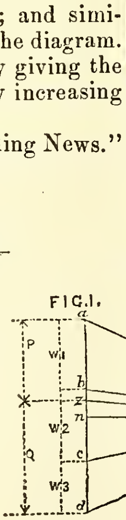
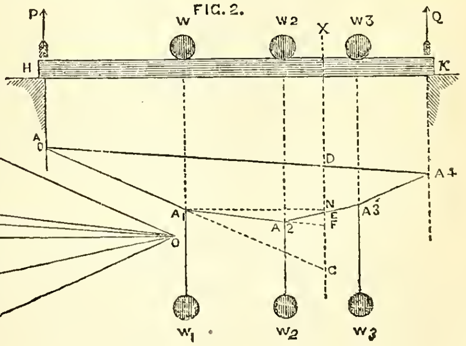


FIG. 2.



example, a beam, H K, supported at H K, and loaded with weights, W_1, W_2, W_3; it is required to find the supporting forces, P Q, and the bending moment at any section, X (Fig. 2).

Set off on a vertical line, ab_1 bc_1 cd, to represent the weights, W_1 W_2 W_3, respectively on any convenient scale (henceforward called the scale of tons.) (Fig. 1.)

Join a, b, c, d, to any convenient pole, O, thus forming a figure which may be called the diagram of forces, and draw the polygon, $A_0 A_1 A_2 A_3 A_4$, with sides parallel to Oa Ob Oc Od, and corners vertically below the supporting forces, P Q, and the load, W_1 W_2 W_3; then A_0 A_1 A_2 A_3 A_3 is the form in which a rope would hang if fixed at A_0 A_4, and loaded with W_1 W_2 W_3, for the sides of the triangles, $O\,a\,b$ $O\,b\,c$ $O\,c\,d$, are parallel to the forces which act at the points A_1 A_2 A_3, respectively. Suppose now A_0 A_4 to be joined, and instead of A_0 A_4 being fixed points, let the side, A_0 A_4, be a solid bar, and the closed funicular polygon thus formed be suspended by strings from the points of support of the beam. Then evidently the tensions of these strings are P Q; thus P Q are immediately got by drawing $O\,z$ parallel to the closing side, A_0 A_4, in the diagram of forces; for, from the equilibrium of the points, A_0 A_4, represented by the triangles, $O\,a\,z$ $O\,d\,z$; $z\,a$ represents P, and $z\,d$ represents Q.

Again, to find the bending moment at any section, X, of the beam, drawing the vertical through X, cutting the sides of the polygon on the sides produced, in D E F G; also draw A_1 N horizontal to meet this vertical in N, and in the diagram of forces, O n, perpendicular to $a\ b\ c\ d$.

Then by similar triangles

$$\frac{F\,G}{A_1\,F}=\frac{a\,b}{O\,b} \text{ and } \frac{A_1\,F}{A_1\,N}=\frac{O\,b}{O\,n}$$

$$\therefore \frac{F\,G}{A_1\,N}=\frac{a\,b}{O\,n}=\frac{W_1}{H}.$$

Where H is the horizontal tension in the funicular polygon represented in the diagram of forces by the polar distance, O n.

$\therefore$ H. F G$=W_1$ .A_1 N$=$moment of W_1 about X.

So in like manner

H. F E$=$moment of W_2 about X,
and H. G D$=$ " P " "
therefore H. D E$=$bending moment at X.

Thus the bending moment at any point, X, of the beam is the force represented by the polar distance O n, in the diagram of forces acting at an arm equal to the length of the intercept, D E, between two sides of the polygon. The rule, therefore, is, measure the polar distance on the scale of tens, and the intercept on the scale of feet; then the product is the bending moment in foot tons.

This result may also be obtained by considering A_0 A_1 A_2 A_3 A_4 as a girder, and applying the method of sections.

The construction here proved for three weights can evidently be extended to any number; its advantage consists mainly in the fact that the position of the pole, O, in the diagram of forces is entirely arbitrary, and can, therefore, be assumed so as to satisfy any convenient conditions. Suppose we require the stress on each bar of a half lattice girder loaded in any way, it will be convenient to choose a polar distance numerically equal to the depth of the girder, for then the intercepts corresponding to any point read off on the scale of feet will be the stress on the opposite bars in tons.

Or again we make the polar distance 10, then the intercept corresponding to any point read off on a decimal scale, with the decimal point moved one place to the right, is the numerical value of the bending moment. Thus a series of bending moments are obtained much more quickly than by any calculation method.

The construction will also be found of considerable value in estimating the effect of a partial load on a girder; an example will show what is meant. Let the beam H K be uniformly loaded between A and B; then to find the bending moment at any point we have only to draw the parabola h a b k, which would represent it if the beam were completely loaded, and at points in the parabola corresponding to a b, draw tangents cutting the verticals through H K in h' k'; then h' k', b a is the polygon for the partial load, the multiplier being the same as for the complete load. (Fig 3.)

The form which the construction assumes, when one or more of the weights is outside the points of support, is interesting. In this case the closing side of the polygon usually intersects two or more of the remaining sides; the corresponding points in the beam are points of contrary flexure, and converse f, if their position is known the polygon of moments is at once determined. For example, let H K be fixed at H, supported at K, and uniformly loaded; assuming the point of contrary flexure, F, we find the corresponding point, f, in the parabola, then $k\,f\,r$ is the closing line, and $h\,f\,b\,k\,f\,r$ is the polygon of moments.

It may be added in conclusion that the shearing force at any point of a beam is known at once from the diagram of forces, thus in the case of the beam first considered, the shearing force is $z\,a$ between P and W_1, $z\,b$ between W_1 and W_2, $z\,c$ between W_2 and W_3, $z\,d$ between W_3 and Q; this enables the stress on the diagonals of a half lattice girder to be obtained from the diagram of forces by drawing parallels to meet a horizontal through z.

Royal School of Naval Architecture, December, 1868.

NOTES.—1. *Der Constructeur.* Van F. Reuleaux, Braunschweig, 1865. 2. Die graphische Statik, Leipzig, 1864.

RAILWAY STATION ARCHITECTURE.

THE LONDON STATIONS—REQUIREMENTS—THE ST. PANCRAS STATION.

The requirements of station architecture are discussed at length by the "Building News," from which we compile the following facts and conclusions. The light and elegant Moorish style is considered peculiarly adapted to iron construction, and hence to station architecture. The classical orders are exclusively for stone. Even the slender Corinthian or Ionic shaft, in iron, is manifestly a sham, and our common sense rebels against it. How, then, is it with the stout Doric column with its massive capital?

The Great Western station at Paddington is cited as at once elegant and suitable. It is in three spans, crossed by two transepts, an arrangement which gives it intricacy and picturesqueness, and conveys an idea of something approaching to comfort, if such a thing can possibly exist in connection with a railway terminus. The girders are pierced in the web with various devices; the columns are light and of Moorish character, and the whole is airy and elegant. The supports to the roof are in the way of nobody, the ventilation is perfect, and the roof is so low that it does not obtrude itself upon the neighborhood; if it did it would not be an offensive object. While Paddington terminus exists let no one say that any other must be either huge or hideous.

The Charing Cross (single span) is one of the monstrosities which it seems to be nobody's business to interfere with while in progress, and everybody's duty to condemn when completed. It is very long, very wide, very high, and very hideous. The walls afford capital accommodation for advertising boards, and this is the utmost that can be said in its praise. Were the walls lower and the roof a complete semicircle it would have been less offensive. It is, indeed, rivalled by the Cannon Street station, and it is difficult to award the palm of supreme ugliness to either without doing wrong to both. The large span is not justified by the plea of freedom from obstruction as to columns for support of two or more smaller spans, inasmuch as the platforms are both here and at Cannon street encumbered with lampposts, which are to all intents and purposes as much in the way as a column to support a girder. Neither is it justified on the score of superior ventilation.

The Southwestern station is in three spans similar to those at Paddington, and the lamps are suspended, not set upon standards. There is no pretension to elegance or ornament, but it accommodates its traffic, is well ventilated, and does not offend the eye.

Other stations in London are mentioned, and the cheapness and suitableness of several low spans, rather than one immense span is advocated. Columns are not objected to. They separate people into two lines and prevent jostling; they form spots where people can harbor and exchange a few words without being elbowed, and where a bag or parcel can be temporarily deposited with less risk than on the open platform.

The King's Cross station exhibits the failure of a too readily adopted constructive principle. For a long time the circular ribs, built up in the laminated method, and consisting of five two-inch planks bolted together, have been losing their shape; they have sunk at the crown of the arch, and are undergoing repairs. It is probable that they will have to be replaced with iron.

THE ST. PANCRAS STATION.—The construction of the new station of the Midland Railway is pronounced excellent. This immense work, recently completed, has been the subject of various essays and illustrations in the London press during the past year. The following graphic description is from the "Railway News." This building has the largest continuous roof of any building in the world. It is 690 feet long, and 240 feet wide. Bare figures, however, fail to convey such an idea of the structure as may be afforded by comparison with others familiar to our readers. The Central Transept of the Crystal Palace is 120 feet wide, or exactly half the width, and 384 feet long, or rather more than half the length of the Midland station. The dome of St. Paul's is 100 feet in diameter; two and a half of these domes might be brought into the station if it were 250 instead of 240 feet wide. Charing Cross station is 168 feet, Cannon street 188 feet wide; the Midland is 240 feet in width, or nearly half as wide again as the roof of Charing Cross.

There is, too, this great feature in the Midland that distinguishes it from all other stations and buildings of its class. There is no network of girders nor of rods intersecting each other at every angle, creating a maze of intricate iron-work, and detracting from the general effect of the bold outline which would otherwise be presented. Enormous iron ribs, in shape something like the monster jaw-bones of whales, and 25 in number, start from the ground on each side, and meet in the centre at an elevation of more than 100 feet above the floor of the station. Iron plates, secured by millions of rivets, build up these ribs, until each of them weighs something like 50 tons, and if bent straight would be 400 feet in length, or nearly the height of St. Paul's Cross from the ground! To prevent the feet of these ribs from starting outward there are fifty huge girders resting upon 1,100 iron columns, more than a foot in diameter, and which, like the string of the bow, keep the frame-work rigid and immovable. To make these binders still more secure, there are 2,000 other iron girders, which cross and recross, and form a network of iron bracing. All this is below the floor of the station, and it supports the roof of four and a half acres of cellars underneath the station.

This large area under the station is to be used for the storage of beer and merchandise, and contains fifteen ranges of cast-iron columns. There are forty-six columns in each range, or six hundred and ninety in all. They stand at about fourteen feet six inches apart. These columns, and the piers upon which the principals rest, have all their foundations upon the London clay. Over the clay is spread a floor of concrete seven feet thick, and upon that a broad sill-plate, upon which the columns are set. The spaces between the intersections of the girders are covered with Mallet's buckle-plates, and a surface is thus provided strong enough to bear, without deflection or rupture, any weight that may be brought upon it. In addition to the binding by the girders, the feet of the principals are further secured by a pair of bolts 24 feet long and four inches in diameter, which pass down through the piers, and are fastened to the anchor-plate below by nuts six inches deep These invisible bindings of enormous strength, are important contributories to the lightness and elegance of the great arch. Along the sides of the station, and outwards to the streets, ranges of arched spaces are built, to be let as shops and places of business. Their fronts, in the Gothic order, and which reach to about the height of the station platform, add greatly to the effectiveness of the immense structure by their quiet enrichments, and by dividing the vast surface of dead wall that would otherwise have been presented.

The walls of the station, unlike those of Charing Cross and Cannon street stations, perform no part in sustaining the roof of the building; this work being thrown, as we have explained, entirely upon the iron ribs which spring from the ground floor. The walls are picked out with white stone; a tesselated frieze of handsome design, inlaid with colored tiles, forms an agreeable ornament, the moulding above which is surmounted by an iron cresting of floral design, the leaves curling inwards from the cornice. Recessed pointed arches and small quatrefoil windows at intervals in the side walls complete the architectural effect as viewed from the interior, which presents a light and agreeable appearance.

The construction of this gigantic roof necessarily involved great difficulties. An enormous traveling stage; similar to that used for the domes of the Exhibition building of 1862, was built up. This stage is 100 feet in length, width 240 feet, depth 90 feet; it contains more than eight miles in length of solid timber, and weighs over 1,300 tons. The huge mass rests upon small wheels, and may be moved about on its tramway as desired, by levers. Such is the extent of the work that there were employed upon the station for the greater part of the time 6,000 men, 1,000 horses, and 100 steam lifts of various kinds.

In the designing, as in the carrying out of this noble station and approaches, Mr. W. H. Barlow has completed a work which will deservedly place his name among those of the most eminent of his profession. The external architecture is the design of Mr. Gilbert Scott. The detail drawings of the iron work were furnished by Mr. Ordish, and the work was supplied by the Butterly Iron Company.

Gigantic Water Works.—A manufacturer of Lyons proposes to supply that town with an amount of water which no city in the world possesses. His plan is to draw from the Lake of Geneva ten tons of water per second, or 864,000 tons in twenty-four hours. The population of Lyons being 330,000 souls, this would give each 2,618 litres of water per diem. Rome, the best supplied city in the world, has 1,500 litres per head per diem, New York 568, Marseilles 470, Bordeaux and Paris each 170, London 110, Brussels 80, Geneva 74, and Lyons, at present, only 60 litres. The proposed canal or conduit would be divided into three sections: (1) An open canal 55 miles long, having a water section 21ft. wide, and about four ft. deep; (2) a covered conduit in masonry, 31 miles long; and (3) nearly eight miles of syphons for the crossings of the valleys.—*The Engineer*.

Good Marine Engineering.—The British iron-clad Hercules, 325 feet long, 59 feet wide, and of 8,600 tons displacement, recently steamed 14.7 knots, or over 17 miles per hour, while drawing 23 feet forward and 26½ feet aft, and developing 8,528 horse power. The remarkable feature is that the engines complete and boilers with water weigh but 1,095 tons, or 2½ hundred weight, per horse power.

MORTON'S EJECTOR-CONDENSER.

Compiled from Prof. Rankine's paper before the Institution of Engineers in Scotland, and the subsequent discussion, and from articles in "Engineering."

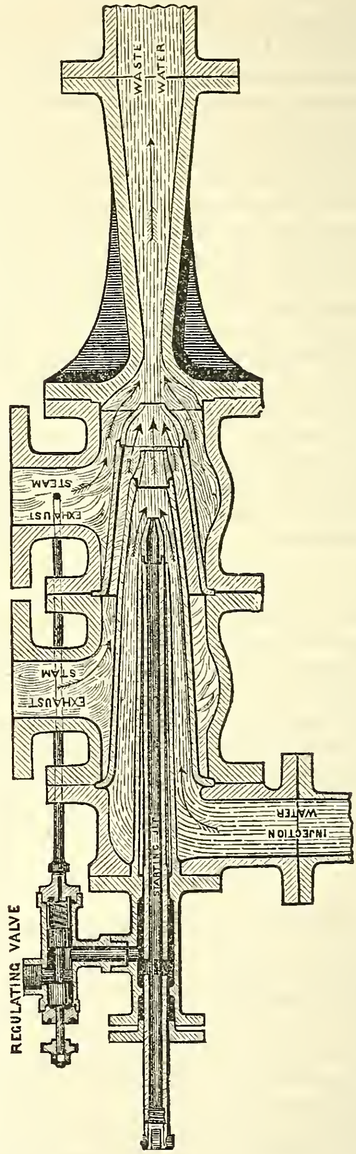
One of the most remarkable devices connected with the steam engine, that has appeared since the Giffard injector, is the condensing apparatus described in this article. Indeed, Professor Rankine pronounces it the most important improvement made in the steam engine, since the days of Watt. Its action is briefly this: While in the ordinary condenser, the force of the steam and water rushing in are entirely wasted, and require a pressure of 0.6 lb. per square inch on the steam piston to pump them out and maintain a vacuum, the Morton condenser utilizes the force of the steam and water entering it, and dispenses with the air pump. The exhaust steam and the condensing water simply rush into a sort of Giffard injector, and instantly come out of it in the form of hot water (and the contained air) without other assistance.

The experiments described were made at the request of Messrs. Neilson Brothers. The ejector-condenser, invented by Mr. Alexander Morton, was applied to a pair of vertical inverted direct-acting steam engines, which exerted collectively a power averaging about 24 indicated horse power. The nominal power of these engines is collectively seven horse power, if we apply the ordinary rule for low pressure engines, or fifteen horse power if we apply the ordinary rule for high pressure engines. The dimensions of the engines and of the condensing apparatus, and the results of the experiments, are given in detail in the annexed table; but as regards the engines it may be convenient to state here that their two cylinders were of eighteen-inch stroke, and about ten and a quarter inch diameter, that they ran at from 93 to 140 revolutions per minute, and that the steam pressure gauge indicated from 30 pounds to 40 pounds on the square inch above the atmospheric pressure, which at the time was 14.75 pounds on the square inch. It may be remarked that the experiments throw light on other questions besides the efficiency of the new condenser; and in particular, that the accurate measurement of of the quantity of condensation water, and of its change of temperature, affords the means of calculating the total expenditure of steam, and comparing it with the quantity of steam effectively used in doing work, as indicated by the diagrams. The circumstances under which the experiments were made were, to a certain extent unfavorable to the apparatus, for the pipe which supplied the tank from which the cold water was drawn for condensing the steam was of too small diameter, and the engines had from time to time to be stopped in order that the tank might be refilled.

Principle of Action.—The principle of the invention may be described as follows: In every injection condenser the cold water rushes into the vacuum with a velocity of 43 feet or 44 feet per second or thereabouts. The exhaust steam rushes from the cylinders into the condenser with a velocity which is many times greater than that of the water. In the common condenser these rapid motions of the water and of the steam are completely checked, and their energy is wasted in agitating the fluids in the condenser, and ultimately in producing heat, and hence it becomes necessary to use an air pump in order to extract the water, air and uncondensed steam from the condenser. The power expended in working a well-proportioned and well-constructed air pump is known by experiment to be equivalent to that which would overcome a back pressure on the steam piston of from half a pound to three-quarters of a pound on each square inch of its area, or, on an average, about 0.6 of a pound on the square inch, and that amount of power is lost through the wasting of the energy with which the jets of water and steam rush into the condenser. In the ejector-condenser the motion of those jets meets with no interruption, and its energy is found to be sufficient, without any assistance from pumps, to carry all the water, air, and uncondensed steam (if any) completely out of the condenser and into the hot well, and thus to save the power which would be required to drive an air pump.

Paradoxical as Giffard's injector appeared, at first sight, its action admitted of perfectly clear explanation. In a boiler under pressure of 100 pounds per square inch, equal to a head of water of 230 feet, the water would rush out of any opening with a velocity (were there no friction, atmospheric resistance, or loss of head) of about 121 feet per second. But were an opposing jet to move with agreater velocity, it would drive back the escaping steam and force its own way into the boiler. This is what happens in the injector, and for a simple reason. A jet of steam moving with a velocity of perhaps 1700 feet per second is instantly condensed in perhaps twelve times its own weight of water. The combined jet will then move with one-thirteenth its former velocity, or about 131 feet per second, the motion of the steam being wholly imparted to the water. Thus the jet, properly directed, enters the boiler. In Morton's condenser, the escaping exhaust steam, properly directed, is condensed in, and its own motion imparted to, a jet of water previously set in motion by a small steam jet, and the experiments appear to show conclusively that the lateral action of the jet is sufficient to draw with it all the air that collects down to a vacuum of twelve pounds or thirteen pounds.

Mr. Morton's explanation of the action is that a jet of water in rushing into the vacuum has nearly sufficient power to take itself out, and the impulse of the exhaust steam from the cylinders makes up the energy that the jet looses in friction.



Description of Apparatus.—The principal parts of the condensing apparatus on which the experiments were made may be summarily described as follows: The cold water passes from the tank to a conoidal nozzle; the area of the orifice of that nozzle is about equal to that of the injection sluice of a common condenser suited for the same engine; that is to say, about $\frac{1}{250}$ part of the collective area of pistons. Enveloping the cold water nozzles are a second and a third nozzle of nearly similar figure; these bring the exhaust steam from the two cylinders respectively. The middle nozzle has an orifice a little larger than that of the innermost, or cold water nozzle; the outermost nozzle ends in a throat or contracted vein, a little larger still, beyond which is a gradually widening trumpet-shaped mouthpiece, leading to a pipe which ends at the hot well. The condensation of the steam takes place in the interval between the orifice of the cold water nozzle and the throat of the outermost nozzle.

When this condenser was first constructed there was no stop-cock for shutting off the injection water, and in starting the condenser it sometimes happened that the attendant would shut off the main steam valve while there was a vacuum in the cylinders, and thus the water was liable to get into them. The inventor has now—that is since Professor Rankine's experiments were made upon the condenser—added a regulating spindle and cylinder, which cylinder contains a piston valve that opens with a spring immediately that the perfection of the vacuum in the condenser is interfered with. By means of this central regulating spindle the injection water current may be most nicely adjusted, or it may even be cut off instantaneously, and the engines can thus be made to work as high pressure engines at pleasure; indeed, its action is so certain and instantaneous that a cylinder full of air may be completely expelled during one revolution of the engine. When the engines are at work, and the regulating valve in action, the latter shuts off the central steam jet; and should any person open a grease cock, or otherwise admit air into either of the cylinders or the condenser, the loss in vacuum is instantly communicated to the regulating valve by the pipe. The action allows the valve to open the steam jet, and thus to displace the air.

While engaged in perfecting this new invention, Mr. Morton experienced the greatest amount of difficulty in connection with the exact parabolic shape which the discharge pipe should assume. This appendage may be regarded as the most important part of the apparatus, for without it the action of the apparatus would be practically useless for a condensing engine, as the steam on leaving the cylinders would require to be much above atmospheric pressure before any water could possibly be discharged. By gradually imparting to the discharge pipe the trumpet-mouth form, shown in the engraving, it was found possible to produce a vacuum of 13 lb. per square inch, with a water pressure on the entering side of the condenser of only two lb.; while to produce a similar vacuum required a water pressure of 50 lb. per square inch if a *vena contracta* nozzle were substituted for the trumpet-mouth of the discharge pipe; or, in other words, a water pressure of 50 lb. could be reduced to two lb. by gradually widening the mouthpiece to its present form, while the vacuum remained the same, and this without the use of any steam in the experiments. Prof. Rankine regards Mr. Morton's application of the trumpet-shaped mouthpiece to the steam engine as being quite a new and original invention, and indeed, as probably the most important improvement in the steam engine since the time of James Watt; and Sir Wm. Thomson considers the production of a vacuum of 13 lb. by the use of this appliance as a most wonderful result in a dynamical point of view.

The Experiments.—Table of experiments made on the 27th October, 1868, on a pair of engines at the works of Messrs. Neilson Brothers:

Cylinders:	
Area of each, allowing for piston rods, about	80 square feet.
Stroke	1.5 foot.
Cold Water Nozzle:	
Diameter 13-16	=0.8125 in.
Area	0.638 sq. in. =0.00443 sq. ft.
Water Tank:	
Area 8 ft. × 3½ ft.	=28 square feet.
Mean depth of surface below level of nozzle	5.25 feet.
Waste Water Nozzle:	
Diameter of throat 15-16 in.	=0.9375 in.
Area of throat	0.690 sq. in. =0.00479 sq. ft.
Diameter of mouth-piece	3.0 in.
Area of mouth-piece	7·07 sq. in. =0.0491 sq. ft.
Cold Water Supply:	
Mean rate of flow in cubic ft. per min., 28 ft.×0.41=11.48	=716.4 lb.
Do. per second, 0.1913	= 11.94 lb.
Velocity of cold water through nozzle, ft. per second, $\frac{0.1913}{0.00443}$	= 43.2 lb. per sq. in.

Head due to that velocity......	29 ft.= 12.57
Add mean height to which water is lifted............	5.25 = 2.275
Total head	34.25 =14.845

Temperature................. 47° Fahren.

Mean work per minute done in raising and propelling water jet, exclusive of friction, 716.4×34.25............. =24537 ft. lb. =0.744 I. H. P.

Barometer: 30.05 in. mercury=14.75 lb. on the square inch.

Sets of Experiments.	Right Hand Cylinder.		Left Hand Cylinder.		
	A.	B.	C.	D.	E.
Nos. of diagrams	1	2.3 4.5	6	7.8	9
Revolutions per minute	130	93	abt. 140	107	108
Steam gauge above atmosphere. Pounds on the square inch	34	from 32 to 38	......	35	from 40 to 30
Do. do. absolute	48.75	from 46.75 to 52.75	......	49.75	from 54.75 to 44.75
Vacuum gauges below atmosphere.* Pounds on the square inch	12.03 11.54	12.4 12.1	....	12.3 11.8	
Do. do. absolute.	2.72 3.21	2.35 2.65	....	2.45 2.95	
Mean back pressure	4.25	3.12	4.50	4.38	4.00
Absolute pressure of release	10.75	10.80	8.75	12.00	10.50
Initial absolute pressure	42.75	38.25	32.75	42.75	42.75
Mean effective pressure	15.25	14.83	9.85	16.78	15.90
Mean absolute pressure	19.50	17.95	14.35	21.16	19.90
Temperature of waste water, Fahrenheit	86.5°	80.5°	......	88.0°	91.0°
Elevation of temperature above cold water....	39.5°	33.5°	......	41.0°	44.0°
Heat carried off by water. British units per minute	28298	23999	......	29372	31522
Velocity of pistons, feet per minute..........	390	279	420	321	324
Load of one piston, lbs	1220	1186.4	788	1342.4	1272
Indicated work, one cylinder, ft. lb. per minute,	475800	331006	330960	430910	412128
" " two "	951600	662012	661920	861820	824256
Indicated H. P............................	28	20	20	26	25
Indicated work per minute reduced to equivalent quantity of heat	1233	858	858	1116	1068
Total expenditure of heat, British units per minute	29531	24857	......	30488	32590
Efficiency of engines	0.042	0.035	......	0.037	0.033
Volume of steam exhausted, as shown by indicator, in cubic feet per minute.............	433	310	467	357	360
Volume of one pound in cubic feet.	35	35	43	32	36
Weight of steam shown by indicator in pounds per minute	12.4	8.9	10.9	11.2	10.0
Temperature of steam at end of stroke, Fahr..	197°	197°	187°	202°	196°
Total heat per pound of that steam from temperature of waste water.................	1087	1093	......	1086	1082
Heat of condensation of steam indicated	13479	9728	......	12163	10820
Heat carried off by waste water (as before)...	28298	23999	......	29372	31522
Actual expenditure of steam in lbs. per minute, as calculated from heat of waste water.....	26.0	22.0	......	27.0	29.1
Proportion in which steam actually condensed exceeds indicated steam..................	2.10	2.47	......	2.41	2.91
Work in foot pounds per minute saved by dispensing with the air pump, estimated as equivalent to 0.6 lb. pressure per square inch of steam piston	37440	26784	40320	30816	31104
Do. indicated H. P	1.13	0.81	1.22	0.93	0.94

* First result is for left hand, and second result for right hand engine.

Abstract of Principal Mean Results.

Mean power saved by dispensing with air pump, indicated horse power	1.0
Mean indicated horse power of engines	23.8
Mean back pressure in cylinders, lb. on sq. in.	4.05
Mean vacuum in cylinders, lb. on the sq. in.	10.7
Mean vacuum shown by gauges, lb. on sq. in.	12.0
Mean vacuum shown by gauges in inches of mercury	24.5

About two-thirds of the indicated power were due to the vacuum in the cylinders.

	deg. F.
Temperature of the cold water	47
Mean temperature of waste water	$83\frac{1}{2}$
Mean increase of temperature	$36\frac{1}{2}$

The completeness and efficiency of the condensation were tested by vacuum gauges, and by indicator diagrams. By both means of testing, the left-hand cylinder, which exhausted into the middle nozzle, showed a rather better vacuum than the right-hand cylinder, which exhausted into the outermost nozzle. The average results of the whole of the experiments were as follows:

Mean vacuum shown by gauges, in inches of mercury	24.5
Mean vacuum shown by gauges, in lb. on the square inch	12.0
Mean vacuum in cylinders, during return stroke, as shown by the indicator diagrams; lb. on the square inch.	10.7
Which, being subtracted from the atmospheric pressure at the time	13.75
Leaves, as the mean back-pressure in the cylinders during the return stroke, in lb. on the square inch	4.05

The back pressure in different experiments ranged between 3 lb. and $4\frac{1}{2}$ lb. on the square inch. These results are at least as good as the average results as to vacuum and back pressure obtained by means of the common condenser; and they show the condensation of the steam and expulsion of the water, air and vapor, to be at least as complete and efficient.

It is estimated that the saving of power through the dispensing with an air pump is equivalent to the doing away with a resistance of 0.6 lb. per square inch area of steam pistons, and it is found to be, on an average of the several experiments, just one horse power, being about 4 per cent of the mean indicated power of the engines. The energy of the jet of cold water is about $\frac{3}{4}$ horse power. This forms the greater part of the energy which is wasted in the common condenser, rendering an air pump necessary.

The temperature of the cold water employed was 47° Fahr., and the temperature of the discharge water was $83\frac{1}{2}$° In common condensing engines the temperature of the discharge water would generally be about 120° with a similar vacuum, a fact which indicates that the new condenser consumer a larger amount of water than is consumed by the ordinary condensing jet. This is admitted, but it must be remembered that the latter gives a much hotter discharge water than the former. There is this fact, also, that the vacuum has recently been improved 1 lb. per square inch by making comparatively trifling alterations in the apparatus. The condensing water has been experimentally reduced $2\frac{1}{2}$ times since the experiment described, with a proportional increase in the temperature of the discharge water and a loss in vacuum of 1.5 lb. The quantity of water now used is stated to be the same as with the ordinary condenser.

As to the height to which the discharge water could be lifted, Mr. Morton states that if the steam leaves the cylinder at about the atmospheric pressure, the water could be forced about 15 ft. high ; a pressure of 5 lb. would force it 20 ft. high.

The abstraction of the air is perhaps the only thing that is really puzzling in he matter, unless it be that the very rapidity with which the steam concentrates upon and within the passing jet of water carries the air wholly against or even into the jet also.

But there is one thing in the record of experiments which requires some explanation. The units of heat imparted to the injection water were from 2.1 to 2.9 times those contained in the heat of condensation of the steam shown by the indicator. Not only this, but the steam represented by the increase of temperature imparted to the injection water amounted to more than 60 lb. per indicated horse power per hour. The different indicated horse powers recorded, the pounds of steam condensed per minute, and the pounds of water consequently used, as steam, per horse power per hour, were as follows, the last column being calculated in "Engineering" from the two first:

I. H. P.	Steam used per Minute. lb.	Water per I. H. P. per Hour. lb.
28	26.0	55.7
20	22.0	66.0
26	27.0	62.3
25	26.1	09.8

The quantity of steam used, representing from 7 lb. to 8 lb. of coal per indicated horse power per hour, appears excessive when the good rate of expansion, good vacuum, and good rate of piston speed are considered. It might be suspected that, notwithstanding the assertion that no steam was used direct from the boiler to keep the jet in motion, the little regulating valve shown in our illustration was open, and thus it might prove that as much live steam was used to work the condenser as to work the engines themselves. This, however, is not said as in any way conclusive, but as a matter requiring explanation.

Cost, Economy and Advantages.—As to cost of construction, Mr. Morton stated that his condenser would not cost more than one-fourth as much as the ordinary condenser and air pump.

The conclusions from the experiments are: First, that the action of the ejector-condenser is at least as efficient as that of the common condenser, with its air pump; and, secondly, that by the use of the ejector-condenser the power required to drive the air pump is saved. The construction is very simple, it has no moving parts which can get out of gear. It can work at any speed of engine, while a high speed of air pump is attended with difficulty; and it overcomes the objection which often arises from placing the air pump horizontally. When the engines are stopped, the vacuum may be maintained for any period of time, by simply opening the central starting steam jet, so as to overcome the friction of the water through the nozzles. The advantage of having a continuous vacuum in maneuvering marine engines in port is of great importance to the marine engineer, especially so in war vessels. In order to maneuver them with facility, in action, this result has been sought in naval vessels by means of independent air pumps. Mr. Morton said that with a small head of water, steam could be wrought down to the finest pressures. H ehad had that engine working at 28in. or 29in. vacuum by adding a head of water of a few feet to that condenser.

Professor Rankine believes that when the apparatus gets fair play, it will give as good results as the surface condenser; at present the results are as good as those with the common injector condenser. While the ejector-condenser is applicable to all kinds of land engines, it seems to be even more especially valuable as an appliance on board river passenger steamers, in which reduction of weight to the lowest possible amount is of the very utmost importance. There is also this advantage in applying Morton's condenser to marine engines, that it may be placed at any height in the vessel, and not necessarily at the lowest level, as is the usual practice with the ordinary form of condenser. It has been suggested that the apparatus might be of still further service in steam vessels by ejecting the water in a direction opposite to that in which the vessel is sailing, and thus assist in its propulsion—acting as a sort of Ruthven's propeller.

The new condenser cannot, of course, give distilled water for the boilers, as is done by surface condensers. Mr. Morton has, it is true, proposed to cool his injection water, originally fresh, by circulating it through a refrigerator, but with water in the hot well, at a temperature of only 80°, or even 110°, or, still more, 120°, it would require a refrigerator many times larger and more costly than a surface condenser to cool it again, by means of sea water at from 50° to 70°, to say nothing of the pumps required for circulating the cooling water.*

That the ejector-condenser is really a very effectual condenser at a low first cost may be inferred from the fact that the Scotch engineers have, in numerous instances, shown an anxious desire, and even a determination to make practical use of the appliance. It has already for some time been in operation at the Lugar Ironworks, in connection with an engine that was made some twenty years ago. Messrs. Robert Napier and Sons, marine engineers and shipbuilders, Glasgow, have lately ordered a pair of engines, with Morton's condensers applied, to be erected at their works at Govan. We understand that Messrs. William Simons and Co., shipbuilders and engineers, Renfrew, are busily engaged in making a pair of twin screw engines on Morton's principle of condensation; and other marine engineering firms on the Clyde are framing their contracts in accordance with their intention to apply the ejector-condenser. Some experiments recently made by Mr. James R. Napier, F.R.S., with the injection water heated to a temperature of 80° Fahr., show that even in warm climates the new condenser will not vary much in vacuum, and that practically it will give a vacuum very nearly equal to that which is due to the temperature. The experiments referred to were so satisfactory that Mr. Napier has resolved, we understand, to apply the Morton condenser to the engines on the Godavery river steamers, built by Messrs. Randolph, Elder and Co., for the Indian Government.

* Lighthall's refrigerator requires no circulating pump.—*Ed. Van Nostrand's Magazine.*

EXAMINATION OF CIVIL ENGINEERS.

Compiled from the "Building News."

A resumé of the questions submitted to candidates for engineer appointments in India. cannot fail to be important to young engineers, and is of interest to general readers. The questions in the first division referred to cements, concrete, mortar, &c. The candidates were required to describe Portland cement, its characteristics, the raw materials from which it is made, and the proportions used. Also the methods of manufacture and the machine, and mode of testing adopted by the engineers of the Metropolitan Board of Works. The proportions of sand to use for mortar had to be stated, and the best qualities of sand for cement mortar named; dimensions and weight of the largest concrete blocks that have been used in harbor works, and a description of the means employed for placing them *in situ*, and where so employed.

The examiner strongly recommends a careful study of Mr. Henry Reid's book, lately published on this subject.* In his remarks on the writing of candidates he advises the cultivation by engineers of a clear, concise, and vigorous style of expression, and he directs their attention to the masterly reports and writings of Smeaton, now unfortunately out of print, but extracts from which, together with those of Watt, Telford, the elder Rennie, Stephenson, Brunel, Locke, and others, he hoped to see shortly published. Such a work, he thinks, would be to the engineer what the Despatches of Wellington are to the military man.

The questions of the second division relate to building materials—brick, stone, timber, &c. Statements were required of the candidates' opinions as to the selection of clay suitable for bricks, its preparation for the moulders, methods of moulding, and arrangements for burning, the latter to be accompanied by a free-hand sketch. Candidates were required to describe the different sizes and kinds of bricks, to illustrate the various bonds employed, and to explain how a bond is sometimes defective in a two-brick wall. A description had to be supplied of the various kinds of stone and timber, and the principal processes employed to preserve the latter from decay and iron from corrosion. The principles of the artesian well, Norton's tube pump, and Mather and Platt's apparatus for well-boring and coal sinking, were required, with particulars of existing wells sunk on the artesian principle. Concrete, now coming more largely into use for building operations, the importance of fuller acquaintance with that material and its capabilities, is insisted on.

The construction of bridges, especially suspension bridges, forms an important part of the examination. Candidates were to describe the difference between the ordinary suspension bridge and a bridge (of which illustrations were furnished) stiffened by suspension rods from the towers to various points in the floor. They had also to state approximately the area of iron required in one of the chains of a suspension bridge having two or more spans of ordinary construction, both at the points of support, viz.: top of tower and at the centre of span; the span being 500 feet, and the versed sine of the curve formed by the chains being 40 feet; the weight of one chain, together with its load, being half a ton per lineal foot, and the strain upon the iron not exceeding five tons per square inch of section. A description of the construction of the Menai, Lambeth, Clifton and Niagara Falls suspension bridges was required, and the spans of the largest bridges hitherto constructed, with the means adopted to obtain a rigid roadway. Free-hand sketches had to be made to accompany descriptions of Mitchell's screws for cast iron bearing piles for piers of bridges, foundation supports for lighthouses, jetties, &c.

The great importance of the study of architecture is strongly insisted upon. The drawing which accompanies the questions is an original design of a range of public offices with a large dome rising in the centre, and flanked by two smaller ones of similar external construction. Candidates were expected to furnish a description of the methods of its erection, to name the style, and to distinguish the different parts. Most of the questions on architecture are of a very elementary character.

The concluding list of questions bears on iron and its applications. The principal things required of the candidate were, statements of the limits in scantling embraced in the trade quotations for "bar iron"—say, in the cases of "flat," "round," and "square" iron; the difference in price of bar iron and angle iron; the limit in dimensions of angle iron comprehended in the said

* And largely compiled without credit from Gen. Gillmore's work on limes and cements.—*Ed. V. N.'s Magazine.*

difference in value, and the usual scale of additional charges for angle iron exceeding the limited dimensions; the price per ton of boiler iron, as exceeding that of bar iron, and the extra charges known in the trade as "best" and "best best;" also, the meanings of the terms "singles" and "doubles;" the comparative costs of steel and iron, with their respective advantages. The concluding question requires by way of answer a description of the process of manufacture of corrugated galvanized iron.

The list of books recommended by the examiner is as follows: "The Roorkee Treatise on Civil Engineering," edited by Major J. C. Medley, R. E.; "The Elements of Practical Hydraulics," by S. Downing, LL. D.; "Practical Treatise on the Manufacture of Portland Cement," by Henry Reid, C. E.; "Irrigation in Southern Europe," by Lieut. C. C. Scott Moncrieff, R. E.; "Italian Irrigation," by Colonel R. Baird Smith, R. E.; "On Public Works in India," by Sir Arthur Cotton, R. E.; "Account of the Ganges Canal," by Colonel Sir Proby Cautley, C. B.; "Ferguson's Works on Architecture."

GAS AS A CALORIFIC AGENT.

"Gas-Light Journal."

While the use of coal-gas for illuminating purposes has extended rapidly, in this country at least, its adoption as a calorific agent has been so slow as to disappoint the hopes of its early advocates. The advantages claimed for gas in this respect are cleanliness and freedom from trouble, it being unnecessary to carry coal or other fuel to feed the fire, or to remove ashes, etc. The rapidity with which heat may be generated and the ability to instantaneously extinguish the fire are great recommendations—particularly in summer when it is desirable to perform the duties of the *cuisine* with as little elevation of temperature as possible.

In England, and particularly in London, gas is largely used for cooking, and it is said to perform its office most acceptably. For families living in apartments, where the trouble and expense of carrying coal or other fuel would be great, gas has proved a great desideratum. By means of approved burners, and admixture with the proper portion of atmospheric air at the time of consumption, a large amount of heat is generated, and where sufficient ventilation may be had, the products of combustion are readily conveyed away, causing no inconvenience or injurious results. Possessing these advantages, it may appear strange that it is not more generally adopted; doubtless it would be, but for the high price of gas in this country; the ordinary methods for generating heat have the preference because of their economy. The probability is that if the price of gas were reduced, so as to make it practicable to employ it for heating, the demand for it would increase in a large ratio, and the concession might be more than atoned for in the enlarged sales which would undoubtedly follow.

That the calorific properties of gas are equal to other agents used for heating, is proved by the fact that in analytical chemical laboratories, charcoal and other fires have been, to a considerable extent, replaced by gas, and the operations of boiling, evaporation, fusion, ultimate organic analysis, and even cupellation, are now performed by easily regulated gas furnaces, their use conducing far more to the personal comfort of the operator, than the troublesome and cumbersome stoves formerly employed. The inventions of gas furnaces, such as are constructed by Griffin and others in England, and Krause and Haskins in this country, have displayed much ingenuity, and, by their use, the laboratory of the chemist presents a much cleaner appearance than formerly—no dangerous sparks or cinders being formed, nor ashes being blown about the room, to the detriment of other substances in the vicinity.

From the success attending the use of gas stoves in the laboratory, it is safe to assert that many of the operations of the household could be performed in the same manner.

The introduction of the improved process of manufacturing gas by the Gwynne-Harris plan of decomposing high steam to produce hydrogen as a heating agent, and for a motive power in lieu of steam power, is commencing a new epoch in the history of political and domestic economy. The same process applied to the ordinary coal gas manufacture lessens the first cost of production so greatly that it will soon be a matter of consideration with gas companies whether the selling price may not be lessened, with a view to its introduction into these new industries; thus opening a much more extensive demand, which, in the aggregate, will largely increase the dividends of gas companies, and add a new element to the progress of the age.

BRIDGE CONSTRUCTION.

Mr. S. S. Post, of New York, has designed an iron bridge for the Mississippi, at St. Louis, having 350 feet clear spans. This work was fully illustrated in "Engineering," July 24. The August 7th number of that journal gives the greater portion of the report of the "Committee on Superstructure and Approaches," at the Convention of Engineers, assembled at St. Louis, August, 1867. To this report figured diagrams for girders 368, 264 and 160 feet long were attached, solely to show the relative maxima of the strains to which the several parts of the girders are subject sometime during the passage of a given, irregularly distributed, moving load. To make the comparison a fair one, the girders were as nearly *similar* in their arrangement, and as uniformly divisible into panels as practicable. Assuming their bearing points to be two feet from the ends, the actual spans were 364, 260 and 156 feet, each of which is a multiple of thirteen feet. The figured diagrams happened to be arranged in consonance with Mr. Post's notions of economy in the use of materials, as exhibited in the design above mentioned. The bays or panels of the horizontal members of the girders were thirteen feet long, except that the chords had a half bay of six and a half feet at each end. The end posts were vertical, but the intermediate ones—the strut braces—were inclined *half a bay.* The heights of the respective girders were three and a half, two and a half, and one and a half bays, making the inclination of their struts one-seventh, one-fifth, and one-third of the height. The tie braces, except the end ones, were inclined 45°, and counter ties were introduced in each panel to the ends of the girder.

To this arrangement a writer in "Engineering" makes two principal objections. 1st. He thinks the counter braces are unnecessary, except "for a short length of the girder at its center"; and, 2d, on account of the particular inclination of the braces. On this latter point he says: "Another feature in the design challenges criticism. The diagonal ties are placed at an angle of 45°, and the struts at an inclination of one horizontal to seven vertical. Now, as we have already said, the useful work done by a strut or tie is the transference of the load towards the piers. It follows, from this, that a *vertical* strut is theoretically of no value at all; it is merely so much additional load on the girder. The load is just as far off its ultimate destination—the pier—when it is transmitted by the vertical strut to the bottom of the girder, as it was when at the top. An infinite number of vertical struts and ties, and, consequently, an infinite weight of metal so disposed, would not transmit the load to the piers. With the struts arranged as in the St. Louis bridge, the load is nearer the pier when transmitted through the strut, to the extent of one-seventh of the depth of truss, and with the ties at an angle of 45°, it is transferred by them a further distance equal to the depth. The question is, whether this total amount of one and one-seventh the depth, the distance which the load is passed on by each triangulation towards its ultimate destination, is as large as it should be. This problem is easily solved. From what has been already advanced, it will be seen that the most economical inclination of tie and strut will be that in which the cost of these members in one triangulation, divided by the horizontal length of same, is the minimum. The proper inclination of the tie and strut will be mutually dependent; with a different construction of strut the angle of the tie would also differ. If struts and ties were the same cost per foot to sustain the same strain, the proper angle would be 45° for both. As the strut is, however, always more costly than the tie, it follows that the economic angle for the tie will be more acute, and for the strut more obtuse than that angle. To determine the most economic angle for the truss we are criticising, we must approximate to the comparative costs of the wrought iron ties and cast iron struts. Assuming the average strain on the latter as one-fourth the amount on the ties per unit of area, and taking the cost per ton of cast iron as one-half that of wrought, we obtain the proportional cost of the strut, for each ton per square inch strain $\times$ one foot long, as double that of a tie under the same conditions. This is a very liberal allowance for the strut; in fact, on De Bergue's system they might be constructed in wrought iron for a considerably less amount."

"Now, if $x =$ the horizontal distance between the two ends of the tie, and $y =$ the same distance in the strut, the useful work done by each triangulation will be the transference of the load the distance $x + y$. Again, the cost of the tie will be proportional to its weight, that is, to the strain upon it multiplied by its length. But the strain also is proportional to the length; hence the cost will be proportional to the square of the length, or in terms of the depth to $1 + x^2$. In the same manner the cost of the strut will be proportional to $2 + 2y^2$. The true measure of the economic value—the cost per foot—will, consequently, be proportional to $\frac{3 + x^2 + 2y^2}{x + y}$. It is only necessary, therefore, to determine the values of x and y when the preceding expression is the minimum. It will be found that $x = \sqrt{2}$, and $y = \sqrt{\frac{1}{2}}$; hence, the inclination of the tie, instead of being 1 to 1, as designed, should have been 1.4 to 1, and of the strut 0.7 to 1, instead of $\frac{1}{7}$ to 1. With the most economic inclination the cost of the web would be proportional to 2.86. With those adopted we obtain by substituting $x = 1$, and $y = \frac{1}{7}$ in the preceding equation, the cost of web proportional to 3.52, exhibiting an excess of some 23 per cent. With vertical struts the cost would be proportional to 4; hence the inclination of the struts, small though it is, effects a saving of 12 per cent. With the struts and ties all at angles of 45°, the cost would be proportional to 3, and the same result would be attained by arranging the ties at an inclination of $1\frac{1}{2}$ to 1, and the struts at $\frac{1}{2}$ to 1, so that considerable latitude is allowed for practical contingencies."

We give, below, the reply* of Mr. Post to the objections raised, and, we think, considering the ability of the parties to the discussion, that it will form an interesting as well as a useful chapter in bridge construction. Mr. Post believes the criticism to be in some respects just, but in other respects he regards the subject under a very different aspect from that assumed by the English writer. He says:

The doctrine that the transference of the weight of the structure and its variable load to the abutments can be accomplished only by means of inclined members, is fully admitted and needs no argument. It is also admitted that both the struts and the ties, connecting the upper and lower flanges, should be inclined. The Reviewer and myself differ somewhat as to the angle of inclination that ought to be given to the ties and to the struts. He will, undoubtedly, concede that acting *alone*, or in pairs, independent of any strut, the tie-brace will produce the greatest useful result when its inclination is 1 to 1, or 45° with a vertical.

Economy in the use of material in a brace requires that the quantity or volume should be the least in proportion to the distance spanned; that is, the greatest economy is when the volume divided by the horizontal reach gives the least quotient; or is a *minimum*. So long as the tie or strut remains vertical the quotient is infinitely great. It is then only an auxiliary, not a direct agent in the transference of the weight toward the abutment.

The strength of the tie depends upon its section, without regard to the length, neglecting its own weight. The section of the tie is always as the weight or stress in the direction of its length. The volume of the tie, when vertical, is proportionate to the product of the length into the weight suspended. When the tie becomes inclined, its length increases as the secant of the angle of inclination, and the stress also increases as this secant. When the maximum useful inclination is reached, this secant becomes $\sqrt{2}$ and the volume of the tie $l\sqrt{2} + W\sqrt{2} = 2\,l\,W$. That is, in passing from the vertical state to an inclination of 45°, the tie doubles its volume.

In the case of a strut, its volume conforms to a very different law in regard to its length and sectional area. Hodgkinson's formula for the strength of a cast iron cylindrical pillar, with rounded ends, and not less than 15 diameters in length, is

$$W = 33379 \times \frac{d^{3.76}}{l^{1.7}} \qquad (1)$$

in which $W =$ the breaking weight in pounds, $d =$ the diameter in inches, and $l =$ the length in feet.

Let $V =$ the volume in cubic inches of a pillar, the section of which is a circle; then

$$V = \frac{\pi}{4} d^2 \times 12\,l = 3\,\pi\,l\,d^2 \qquad (2)$$

From equation (1),

$$d^{3.76} = \frac{W\,l^{1.7}}{33379};\ d = \left(\frac{W\,l^{1.7}}{33379}\right)^{\frac{1}{3.76}};\ d^2 = \left(\frac{W\,l^{1.7}}{33376}\right)^{\frac{1}{1\ 88}} \qquad (3)$$

Substituting this value of d^2 in equation (2).

$$V = 3\,\pi\,l\left(\frac{W\,l^{1.7}}{33376}\right) = 3\,\pi\left(\frac{1}{33376}\right)^{\frac{1}{1.88}} \times W^{\frac{1}{1.88}} \times l^{\frac{3.58}{1.88}}. \qquad (4)$$

* "Engineering," Jan. 8, 1868.

$$V = 0.036998 \times W^{\frac{1}{1.88}} \times l^{\frac{3.58}{1.88}}. \qquad (5)$$

From this it appears that the volume of a cast iron strut increases as the 0.35+ power of the weight imposed, and the 1.9+ power of the length.

Now, assuming the vertical height or altitude to remain constant, when the strut becomes inclined, its length increases and its stress also increases, both as the secant of the angle of inclination and its volume is greatly increased.

Putting V_1 for the new volume, m for the exponent $\frac{1}{1.88}$, n for $\frac{3.58}{1.88}$; $A=$ the coefficient 0.036998, $W=$ the weight, and $l=$ the altitude, as before, and make $x=$ the tangent of the angle of inclination, then $lx=$ the base or horizontal run of the strut, and $(l^2+l^2x^2)^{\frac{1}{2}}$ will be the length of the strut. $W\left(\frac{l^2+l^2x^2}{l}\right)^{\frac{1}{2}}$ will be the stress on the strut. Then (6)

$$V_1 = A \times \left(\frac{W\sqrt{l^2+l^2x^2}}{l}\right)^m \times \left(\frac{l\sqrt{l^2+l^2x^2}}{l}\right)^n \qquad (7)$$

$$V_1 = A \times W^m \times l_n \times \left(\frac{\sqrt{l^2+l^2x^2}}{l}\right)^m \times \left(\frac{\sqrt{l^2+l^2x^2}}{l}\right)^n$$

$$V_1 = A \times W^m \times l^n \times \left(\frac{\sqrt{l^2+l^2x^2}}{l}\right)^{m+n} \qquad (8)$$

$$V_1 = A \times W^m \times l^n \times \frac{(l^2+l^2x^2)^{\frac{m+n}{2}}}{l^{m+n}} \qquad (9)$$

From this subtracting equation (5)

$$V_1 - V = \frac{(l^2+l^2x^2)^{\frac{m+n}{2}}}{l^{m+n}} \qquad (10)$$

is the increased volume of the strut in consequence of its inclination.

But by the condition of the question V_1 gives a minimum when divided by the base (lx), that is

$$\frac{V_1}{lx} = A \times W^m \times l^n \times \frac{(l^2+l^2x^2)^{\frac{m+n}{2}}}{lx \times l^{m+n}} =$$

a minimum.

$$\frac{V_1}{lx} = \frac{A \times W^m \times l^n}{l^{(m+n+1)}} \times \frac{(l^2+l^2x^2)^{\frac{m+n}{2}}}{x}$$

Suppressing the constant value $\frac{A \times W^m \times l^n}{l^{(m+n+1)}}$ and differentiating the variable function

$$\frac{(l^2+l^2x^2)^{\frac{m+n}{2}}}{x} \cdot d\frac{(l^2+l^2x^2)^{\frac{m+n}{2}}}{x} = o$$

when the value is a *minimum*. Consequently

$$x^2 \times (m+n) \quad (l^2+l^2x^2)^{\frac{m+n}{2}-1} = (l^2+l^2x^2)^{\frac{m+n}{2}}$$

$$(m+n).x^2 = \frac{(l^2+l^2x^2)^{\frac{m+n}{2}}}{(l^2+l^2x^2)^{\frac{m+n}{2}-1}} = l^2 \times l^2x^2$$

$$(m+n).x^2 - l^2x^2 = l^2; \quad (m+n-l^2)x^2 = l^2$$

$$x^2 = \frac{l^2}{(m+n-l^2)}; \text{ and } x = \frac{l}{(m+n-l^2)^{\frac{1}{2}}}$$

Putting $l =$ *unity*. $\quad x = \frac{1}{(m+n-1)^{\frac{1}{2}}}$

Restoring the numerical value of m and n and reducing them to the decimal form

$$x = \frac{1}{\sqrt{0.5319149+1.9042552-1}} = 0.8344437,$$

which is the tangent of 39° 50½′ very nearly, and not 45° as in the case of the tie, and as the Reviewer asserts should be the angle of the strut also, if the cost for both were the same. The correct inclination of the tie when used without reference to a connecting strut is 45°, and the correct inclination of the strut, without regard to a connecting tie is 39° 50½′. But it unfortunately happens that the base of one is not a multiple of the base of the other. It is practically of great importance that all the bays of the top and bottom flanges should be of the same length. Floor beams and other laterals, of one pattern, can then be used for all the triangulations. Various other reasons can be given why the truss in this respect should be symmetrical, but they are sufficiently obvious. The cost of a strut, if made solid, will be much greater than if made hollow, but the theoretical angle of inclination will be the same in both cases.

Brevet Col. Wm. E. Merrill, U. S. Engineers, has obtained a very ingenious formula for the weight of a hollow cast iron cylindrical pillar of maximum strength for its volume. This formula is deduced from Hodgkinson's experiments. It appears to me to be very accurate, and although unpublished, I will take the liberty to use it here. It is

$$P = 0.004599558 \times W^{0.5319149} \times l^{1.9042553}$$

in which $P=$ the weight of the pillar in pounds; $W=$ the breaking weight in pounds and $l=$ the length in feet.

Suppose the height of the truss to be 45½ feet from center to center of the flanges (as in the case of the long span for St. Louis), and the panel weight 180,000 pounds. Suppose the tensile strength of a wrought iron tie is 60,000 pounds per square inch of its sectional area. A vertical tie that will just break under this load, will have a section of three square inches, and weigh $45\frac{1}{2}+3+3.38=460$ pounds, very nearly. And a tie inclined 45° will have a section of six square inches and weigh 920 pounds. In both these cases the necessary enlargement at the ends for eyes or for thread and nuts is not included. The ends of the struts will also require enlargement for similar purposes, and as this enlargement will be nearly proportional to the whole weight in both ties and braces, they may here be totally neglected.

The weight of a vertical strut $45\frac{1}{2}$ ft. long, loaded with 180,000 pounds, will be

$$P=0.004599558\times(180000)^{0.5319149}\times(45.5)^{1.9042553}=4124 \text{ pounds.}$$

If the strut be inclined to its best theoretical angle of 39° $50\frac{1}{2}'$ its length will be increased 59.26 feet, and the stress to 234,444 pounds. Its weight will be

$$P=0.004599558\times(234444)^{0.5319149}\times(59.26)^{1.9042553}=7698 \text{ pounds.}$$

By making the inclination of the strut $\frac{1}{3}$, the length will be 47.96 feet, the stress 189,737 pounds, and the weight of the strut

$$P=0.004599558\times(189737)^{0.5319149}\times(47.96)^{1.9042553}=4676 \text{ pounds.}$$

Assuming the cost of wrought iron to be double that of the same weight of cast iron, the cost of the wrought iron tie, under an inclination of 45°, may be represented by $920\times2=1840$. The cost of the vertical strut will then be represented by 4124. The combined cost of the tie and strut will be $1840+41245=964$. Calling the horizontal run of the tie = the height of the truss = unity, then the economy in this case is represented by 5964. Taking the tie at an angle of 45°, and the strut at an angle of 39° $50\frac{1}{2}'$, the economy of their combined use is

$$\frac{1840+7698}{1.834437}=5145.$$

In this case, where both the tie and strut have their theoretic angles, there is a saving of only 16 per cent. over having the strut vertical, and a saving only $\frac{1}{3}$ greater than is admitted by the Reviewer when the inclination is $\frac{1}{7}$. When the inclination of the strut is $\frac{1}{3}$, and the tie $\frac{1}{1}$, the economy of their combined use is represented by

$$\frac{1840+4676}{1\frac{1}{3}}=4812,$$

showing a saving of nearly 24 per cent. in the cost.

The pamphlet containing the description of the truss under review, also contains the description of other trusses proposed, in some of which the inclination of the strut brace is $\frac{1}{3}$, in some others it is $\frac{1}{5}$, and in others it is $\frac{1}{7}$ the height of the truss. Nowhere is it pretended that either of these inclinations is theoretically correct, but each one, under the circumstances attending its use, is *practically* the *best* that could be given it. When a tie can be used at an angle of 45°, I do not quite comprehend the philosophy of abandoning what is absolutely its best position because a contiguous strut cannot assume *its* best position also.

From the vertical to an inclination of 39° $50\frac{1}{2}'$, the cost ranges from $2\frac{1}{4}$ to $4\frac{1}{5}$ times the cost of the tie inclined 45°; of course the expression $\frac{3+x^2+2y^2}{x+y}$ does not apply to the case, and all deductions therefrom fall.

The relative cost of struts inclined at various angles, coupled with a tie at 45°, will be considerably modified by the difference that may be made between the ultimate strength and a safe working strength. If 6 be introduced as the factor of safety, the cost of the wrought-iron will be increased to six times, while that of the cast-iron will be increased to only $6^{0.53+}=2.5937$ times.

The relative cost will then be for tie 45°, and

Strut *vertical*,

$$\frac{1860\times6+4124\times2.5937}{1}=11040+10596=21636.$$

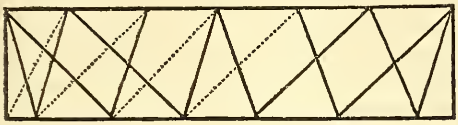
Strut inclined 39° $50\frac{1}{2}'$,

$$\frac{11040+17966}{1.83444}=\quad 15766.$$

Strut inclined $\frac{1}{3}$.

$$\frac{11040+12128}{1\frac{1}{3}}=\quad 12376.$$

That an American engineer should act upon a theory different from that long held on the other side of the Atlantic, as to the value or usefulness of counter braces (so called), seems to excite the most surprise in the mind of the Reviewer. He asks, "Upon what hypothesis are the computed strains on the counter braces based?" In answering this question reference is made to the following diagram:



The strains upon this girder resulting from the permanent load, or from one-half the weight of the bridge itself, are symmetrical about the middle point D. Of course the opposite halves are perfectly balanced, whether the girder be composed of the finest steel or of the coarsest lead. The weight of the structure may be assumed indefinitely small or indefinitely great. In either case any accidental load will disturb the balance. Let W represent a panel weight of this permanent load, whatever it may be; then the portion of the permanent load transferred to the abutments (a a') by the inclined braces will be, by

$B\,d$ and $B'\,d'$ each W, and the strain will be $W\times$ Sec. $\angle$.
$A\,c$ and $A'\,c'$ each W, and the strain will be $W\times$ Sec. $\angle$.
$A\,b$ and $A'\,b'$ each $1\frac{3}{4}W$, and the strain will be $1\frac{3}{4}W+$ Sec. $\angle$.

Under such a condition there can be no *use* for counter braces, represented by dotted lines in the left hand half of the diagram.

Now, supposing the variable or moving load, consisting of a very heavy engine, occupying the length of two panels, followed by its tender and a train of cars, be brought upon the bridge from the left—

Let $e=$ a panel weight of the engine per truss;

Let $t=$ a panel weight of the tender, and

Let $c=$ a panel weight of cars.

On arrival of the engine at b', that point receives a special load $=\frac{3}{4}\,e$, which is not balanced by a corresponding load at b. A new state of equilibrium in the truss instantly occurs. Of this additional weight $\frac{1}{12}\times\frac{3}{4}\,e=\frac{1}{16}\,e$ has been transferred to a, and $\frac{11}{12}\times\frac{3}{4}\,e=\frac{11}{16}\,e$ has been transferred to a'. The result would have been exactly the same if the train had entered from the right, only that of the special weight now at b, $\frac{1}{12}$ would be transmitted to a', and $\frac{11}{12}$ to a.

Through what channels is the transference of the lesser weight made in the two cases? It seems to me that when the moving load enters from the left, the tie $C'\,b'$ will be *used* for this purpose; but the load coming from the right, it is certain that where no tie $C\,b$ exists, it is of *no use*. How, then, when the moving load comes from the right, is the weight $\frac{1}{16}\,e$ transmitted from b to a'? Is it not *first* by tension on the strut $B\,b$; *second*, by compression on the slender tie $B\,d$; *third*, by tension on the strut $D\,d$, when having reached the centre point D, which it would also have reached by way of counter braces, it then pursues its legitimate course to a'.

How, it may be asked, supposing the strut $B\,b$ to be removed so as to close this channel of communication, is the $\frac{1}{16}\,e$ to be transmitted to a'? If the corresponding strut ($B'\,b'$) at the other end were also removed, there would obviously be a collapse. Perhaps the horizontal force $\frac{11}{48}\,e$ may contain in a latent state the transmitted weight $=\frac{1}{16}\,e$ $=\frac{3}{48}\,e$ of vertical force, which is set free on the first opportunity by reaching the next inclined member ($C\,c$). However this may all be, $\frac{1}{16}\,e$ must be transferred from b' to a', and it is not easy to conceive in what way the weight of the structure itself can influence this transference. Undoubtedly the simplest means of transferring this $\frac{1}{16}e$ from b' to a', would be by inserting a tie from b to A', but the arrangement of the parts of the girder forbids. The simplest practical means left is to insert ties tending in the desired direction.

To return to the effect of the moving load entering the bridge from the left: when the engine has reached b', $\frac{3}{4}$ of a panel weight of the engine will rest at that point, $\frac{11}{12}$ of which will be supported by the tie $A'\,b'$, and $\frac{1}{12}$ transmitted towards a. Now, if a tie exists from b' to C' tending in the direction the weight is to be transferred, and if this tie be more direct than any other inclined member, the $\frac{1}{16}\,e$ will inevitably take such route. All the ties parallel to $C'\,b'$ will be equally affected by the $\frac{1}{16}\,e$.

The partial load at $b'=\frac{3}{4}\,e$, is divided into $\frac{11}{12}\times\frac{3}{4}\,e=\frac{33}{48}\,e$, which is sustained by the tie $A'\,b'$, and $\frac{1}{12}\times\frac{3}{4}\,e=\frac{3}{48}\,e$, sustained by the tie $C'\,b'$.

The horizontal force developed in the horizontal tie $b'\,c'$ is $(\frac{1}{3}\times\frac{11}{12}-\frac{1}{12})\times\frac{3}{4}\,e=\frac{8}{48}\,e$ and in the tie $C'\,b'$ $\frac{3}{48}\,e$, assuming always that the long ties have an inclination of 45°. Then the strain on the tie ($C'\,b'$) at a certain moment is $\sqrt{2}\times\frac{3}{48}\,e$. This is a *positive* strain, and no weight or inertia of the structure can relieve it. The numerical results of this strain can be given "to the smallest fraction" when a numerical value for e is assumed. It is the *maximum* strain. It does not become *negative* because the permanent weight of the bridge acts against it, as assumed by certain writers.

The maxima of strains at any time affecting the several ties while the train passes the bridge will be—

On B' a' nothing.
On C' b' $\sqrt{2}\times(\frac{1}{12}\times\frac{3}{4}e)$.
On D c' $\sqrt{2}\times(\frac{3}{12}e+\frac{1}{12}\times\frac{3}{4}e)$.
On C d' $\sqrt{2}\times(\frac{5}{12}e+\frac{1}{2}\times\frac{3}{12}e+\frac{3}{48}t)$.
On B d $\sqrt{2}\times(W+e+\frac{3}{24}t+\frac{3}{96}c)$.
On A c $\sqrt{2}\times(W+\frac{9}{12}e+\frac{5}{12}t+\frac{15}{96}c)$.
On A b $\frac{1}{3}\sqrt{10}\times(1\frac{3}{4}W+\frac{11}{12}e+\frac{7}{12}t+\frac{15}{96}c)$.

Here it is found that the computation of the maximum strain in the several ties is a problem "capable of the most rigid solution," notwithstanding the strains on contiguous braces vary so considerably in the gross amount. When the material of these braces and of all the other parts is properly proportioned to meet the strains, the bridge may be considered in its normal condition, at least so far as the transmission of loads in the early lifetime of the bridge is concerned.

We have been informed, on the authority of such men as Eaton Hodgkinson, W. Cubit, Geo. Rennie, Henry James, Robert Willis, and Lord Wrottesley, that upon an iron bridge of 48 feet span an engine and tender weighing 39 tons, at a speed of 50 miles per hour, in consequence of the bridge having a static deflection of $\frac{1}{5}$ inch, the speed increased the deflection $\frac{1}{7}$, or to what would be due to a weight of about 45 tons. If, then, a slight static deflection causes the moving load, under a velocity that is not unusual, "to exercise the same pressure as if it had been increased by $\frac{1}{7}$, and placed at rest upon the centre of the bridge," I do not see, with the Reviewer, that "an inch more or less is a matter of no moment at all in the deflection."

The maximum variable load carried by the tie B' d' and by the strut B' b' is $(e+\frac{3}{24}t+\frac{3}{96}c)$.

Under this variable load more or less deflection occurs at b'. If, now, the tie B' a' be inserted and screwed up to the slightest degree of initial tension, not so as to increase the pressure on the strut, when the engine passes off the bridge, the strut B' b' must remain under the same pressure as before, in consequence of its reaction on the tie B' a'.

Bringing the engine back to d', the tie B' d' is again loaded, and the tie B' a' relieved. No change in the deflection at b', nor difference in the pressure on the strut has occurred. On this principle the strains on the counter braces for the bridge at St. Louis were computed. If it were possible to construct a bridge perfectly level and straight, so that it would have no static deflection, whether loaded or unloaded, its dynamic deflection, however great the speed, must be very little.

In calculating the strains upon the St. Louis bridge, the moving load was not considered as uniformly distributed, consequently the maximum strains on the flanges do not occur at the middle of the span. Hence, $28\times61635=1.725780$ pounds, is not the correct maximum strain on the top flange. It cannot, therefore, be fairly inferred from such a calculation that some initial strain is assumed on the counter braces when the bridge is fully loaded, nor that the condition is such as "involves the provision of greater strength in the diagonal struts and ties than is absolutely required for the useful duty they have to perform."

STEEP RAILWAY GRADIENTS.

At the present time, when attention is being again directed to the unsatisfactary working of the Mont Cenis engines with their horizontal gripping wheels and attendant complications, it is worthy of note that during the construction of the Ottoman railway, Mr. T. R. Crampton made regular use of, and worked by an ordinary contractor's engine, a tramway laid for a length of 800 yards to a gradient of one in eleven. This tramway was altogether about a mile long, and for 800 yards of this length it rose, as we have said, at an inclination of one in eleven, afterwards descending for about the same distance with inclines of one in fifteen and one in twenty. About 200 yards of the gradient of one in eleven consisted of curves of 400 feet radius. The tramway was employed for the conveyance of materials to be used in the construction of the main lines, and during six months about 10,000 tons were carried over it. It was worked by an ordinary contractor's locomotive, built by Mr. Hughes, of Loughborough; this engine having cylinders eleven inches in diameter by eighteen-inch stroke, and two pairs of coupled wheels two feet six inches in diameter, placed four feet six inches apart from centre to centre. The weight of the engine in working order was ten tons, and it drew behind it a load of thirteen tons up the gradient of one in eleven. The pressure of the steam was from 90 pounds to 100 pounds per square inch.

On an incline of one in eleven, the resistance due to gravity would be 203.64 pounds per ton, and taking the engine friction at eighteen pounds per ton, and the wagon friction at ten pounds per ton, we have the following total resistance to be overcome by the engine in ascending the gradient:

	Pounds.
Resistance due to gravity: 23 tons at 203.63 lb. per ton	4,683.5
Engine friction: 10 tons at 18 lb. per ton ..	180
Wagon friction: 13 tons at 10 lb. per ton ..	130
Total	4,993.5

or, say, 5,000 pounds. The weight available for adhesion was ten tons, or 22,400 pounds, which would be diminished by one-eleventh on an incline of one in eleven. The actual adhesion weight available in the incline would, therefore, be—

$$22{,}400-\frac{22{,}400}{11}=20{,}364 \text{ lb.},$$

and the adhesion must, therefore, have amounted to very nearly one-fourth of the load on the wheels. An engine of the dimensions above given would develop a tractive force of—

$$\frac{11^2\times 1.5}{2.5}=\frac{121.\times 1.5}{2.5}=72.6 \text{ lb.},$$

for each pound of effective pressure per square inch on the pistons; and to overcome the tractive pressure of 5,000 pounds, this effective pressure must thus have been $\frac{5{,}000}{726}=68.6$ lb. per square inch. This pressure on the piston could, of course, readily be maintained by a boiler pressure of 90 pounds per square inch.—*Engineering.*

Roman Mortar.—The Roman mortars were essentially different from ours; they were composed, with a few exceptions, of pure lime mixed in large proportions with fragments of bricks coarsely pounded. This mortar formed the bottom and side lining of cisterns, fish-ponds, aqueducts, &c. Probably the introduction of the dry substances was for the purpose of hastening the solidification by exhausting the superabundance of water from the lime. Thus, probably, the desiccation of the mortar was obtained and its compactness and impermeability to water secured. The lime, sand, and brick of these mortars were those of the country where the structures into whose composition they enter now exist.

PHOTOGRAPHY.

PICTURES OF THE ECLIPSE—PERMANENT PHOTOGRAPHS.

From the "Mechanics' Magazine."

The total eclipse of the sun, visible last August in equatorial Asia, has called special attention to astronomical photography, and this branch of the science will doubtless be considerably improved before it is brought to bear next August upon another total eclipse, visible throughout a large portion of the United States. The recent photographic operations of the English expedition to India proved a failure, because of the want of a skilled photographer upon the staff. The plates were spoilt, because of the drying of the silver solution upon their surfaces, and they were all under-exposed. The first of these mishaps may always be avoided, and the German expedition at Aden avoided the latter by trying some experimental plate shortly before the totality, to get some clue beforehand to the decline in the actinism of the light produced by the eclipse. Next year, more pictures may be obtained in the same space of time, by adopting the plan of the Germans at Aden, of taking two pictures of the eclipse upon one glass plate. This is done by a simple plan well known to photographers. The sliding dark back, carrying the plate, is lengthened, so that after one picture is taken, and the light cut off, the slide is moved onwards two or three inches, and another picture taken upon the same film. This plan saves half a minute, or more, which otherwise would be lost in changing the slides.

The English apparatus worked capitally during the eclipse, but even in this the German expedition had one slight improvement. The photographic part of their apparatus was not directly fixed to the tube of the telescope, lest the necessary motions of the slides should set up vibrations, so the connection was made by means of an india-rubber tube, which also excluded all stray light. In ordinary photographic operations, if the operator desires to get the maximum number of negatives in the shortest space of time, he not only furnishes his camera with a long sliding back, but he increases the number of his lenses, to throw several similar pictures upon different parts of the same sensitive plate. This raises the question whether in photographing solar eclipses it may not be possible to mount two or three reflectors or refractors at the end of a single telescopic tube, so that, say, three pictures are thrown at once upon the plate in a vertical line one above the other. Then, by shifting the plate as already described, six pictures would be obtained upon one film; or, by a second motion of the plate, even as many as nine might be impressed.

Many plans for increasing the permanency of photographic prints have been under consideration at the various societies during the past year, but the results, as regards pictures upon albumenized paper, have been small. The very few photographers who are really scientific men, turn out silver prints which in comparison with the general run of such pictures, are stable, fresh and good, hypo-sulphite of soda solution, and thorough washing of the prints after fixing, being the best guarantees of permanency. After the washing and mounting of such pictures, rolling and waxing seems to increase the stability, by the production of a print with a hard glazed surface, somewhat protected by the wax from deleterious impurities in the air. But no care in silver printing upon albumenized paper seems to give security against fading in the long run, and no photographic chemist of eminence would risk his reputation by the assertion that any such silver pictures are as durable as engravings in printing ink. Messrs. Disderi, Johnson, and others, have been producing some very delicate and beautiful prints upon wet collodion, which prints were afterwards transferred to paper. Little or nothing is as yet practically known about the durability of these pictures, but theoretically there are reasons for supposing that they will last longer than the common kind. At all events, they are more pleasing and engraving-like in appearance, and can be turned out at the same price as their better-known rivals.

Carbon was the basis of the best and most imperishable of the inks in use by the monks of old, and there is no doubt that the most permanent photographic pictures at present obtainable upon paper are those produced by the carbon process. Mr. Joseph Swan first produced these pictures upon a commercial scale, and after working the process up to a great state of perfection, he recently sold his patent for a high sum to a London Company, but there is scarcely a phhotographer in London who will undertake to supply carbon portraits on any terms whatever. One of the best and certainly one of the most beautiful kinds of permanent photographic pictures are transparencies upon collodion, cemented between two sheets of glass with Canada balsam. The balsam in its natural state will not do, as the essential oil it contains gradually evaporates, and at last the picture ceases at places to remain in optical contact with the glass. This essential oil should first be driven off by heat to such an extent that the balsam hardens as it cools, and this hardened balsam should be used in cementation processes. Even this, in some cases, tends to become brittle with age, whereby the plates have a liability to split asunder too easily, so that experiments are desirable to ascertain the best substance to mix with the balsam to increase its toughness.

This question of durability of photographs is of far more national interest than is apparent at first sight. If photography had been known in the days of Queen Elizabeth, and the photographers of that time took nothing but fading pictures, so that that the London life of the period was thereby pictorially lost to us for ever, except in the imperfect wood cut and flattered oil portrait, what censure we should now heap upon the photographers of old. Yet the photographers of to-day stand a good chance of falling into similar disrepute in the opinion of posterity. Month by month the physical features of all our cities are changing with great rapidity. Railways are cutting up the old streets and new streets are being cut through in all directions. Little is thought of these changes at the time they are made, but after the lapse of a few years, accurate pictures of our cities as they used to be, will begin to grow in public interest.

THE BESSEMER PROCESS.

PIG IRON—BLAST AND BLAST PIPES—RECARBURIZER.

From "Engineering."

In the practical management of a Bessemer steelworks the selection of pig iron is one of the most important questions. It is well known that the percentages of silicon, carbon, manganese, sulphur, phosphorus, and copper, must all correspond to certain figures ascertained by experience, or must at least remain within certain very narrow limits, in order to insure a complete reliability and regularity of practice and a high quality of the metal produced. The percentage of silicon should not be below 1 per cent., and not above 2 per cent.; the percentage of carbon should never be below 3 per cent., but ought to be as high as possible. The presence of manganese to a certain extent replaces that of carbon; but the pig iron charges should not contain more than 3 per cent. of manganese, because the great affinity of manganese for oxygen causes a very violent action in the converter, resembling a series of explosions, by which a great quantity of metal is thrown out of the vessels. Silicon is an antidote against this violent action of manganese, and a charge of manganesic pig iron, mixed with a suitable proportion of pig iron, containing about 3 per cent., or 3.5 per cent. of silicon, works quietly, and gives an excellent product. In a similar manner it is a very advantageous practice to mix pig iron which is overcharged with silicon with a proportionate quantity of spiegeleisen in making up the charge for the converter. The charge requires at least 2 per cent. of manganese for every per cent. of silicon which it holds in excess of the requisite quantity, say 1½ per cent. When the pig iron is melted in an air furnace the percentages of carbon, silicon, and manganese are sensibly diminished by the ordinary influence of the flame; this effect, to a certain extent, depends upon the management of the melting furnace, and the attention of the operator should be directed to the prevention of an excessive oxidation in the air furnace. When a cupola is used for melting the pig, or when the pig iron is run direct from the blast furnace into the converter, the proportionate quantities of carbon, silicon, and manganese named above may be slightly reduced.

The distinction which is made between combined and uncombined or graphitic carbon, when judging of the applicability of pig iron for the Bessemer process, is a prejudice. The total percentage of carbon, both combined and uncombined, is the only criterion, as far as the applicability to the Bessemer process is concerned. Sulphur, phosphorus, and copper are limited to the extremely small percentage of 0.05 per cent. whenever a high quality of metal is to be produced. From this it does not, however, follow that no pig iron which contains a higher percentage of either of those three impurities can be employed with advantage. By mixing different kinds of pig iron in a judicious manner, it is possible to dilute the impurities, and bring them down to the normal percentages. In making up a charge from three different kinds of pig iron, for instance, one-third of the charge holding 0.15 per cent. of sulphur, the second contaminated with phosphorus to the same extent, 0.15 per cent., and the third part of the charge containing 0.15 per cent. copper, it is obvious that the mixture of liquid iron charged into the converter comes within the limits named above, and is perfectly suitable for the production of the best qualities of Bessemer metal, although none of the classes of pigs from which that charge was made up could have been by itself employed for the Bessemer process.

The pig iron, when selected and made up into a charge, should be melted rapidly, and at the highest temperature which can be produced. The runners or channels through which the iron passes into the converter must be of large sectional area, and carefully dried and heated previous to tapping. The converter must have a full white heat before receiving the charge, and the liquid iron must be run into it as rapidly as is compatible with safety and cleanliness. The converter should never be turned up before the safety valve upon the air vessel has commenced to blow off, and the blast is let on full before the converter is brought into an upright position. The liquid column of iron in the converter is from 12 to 14 in. deep. This depth is not exceeded in the converters of larger sizes, which have a larger diameter and a correspondingly greater number of tuyeres, so as to hold the greater quantity of metal without increasing the depth of the ferrostatic column. The blast pressure in the air vessel varies from 12 to 25lb. on the square inch, and it is never less than three times as great as the weight of the liquid column which rests upon the tuyeres. This shows that the back pressure caused by the liquid column bears only a comparatively small proportion to the total sum of resistance presented to the passage of the blast through the Bessemer apparatus.

The resistance which the blast must overcome in passing through the converter is made up, first, of the friction and other loss of power in the pipes and passages between the air vessel and the tuyere box; second, of the friction and resistance caused by the numerous and narrow holes of the tuyeres; third, of the head of liquid column covering the tuyeres and the friction within the liquid metal; and fourth, of the friction and resistance caused by the contracted flue or mouth of the converter. The sum total of these resistances offered to the blast in passing through the vessel is measured by the pressure gauge, on the platform, and it is obvious therefore that the variations of pressure, as indicated by the gauge, do not of themselves show to which particular item any fluctuations are due. The burning and shortening of the tuyeres may lessen the friction, or the partial choking reduce the area of passage; the iron may become more or less fluid; the throat may be partly filled with slags, and thereby reduced in area; or a leak in the pipes may cause a loss of air pressure: all these and many other causes, which by their simultaneous action interfere with each other's individual effects upon the pressure gauge, make the indication of that instrument more or less confused and difficult to understand. It is preferable to look to the behavior of the converter instead of to the indications of the pressure gauge in controlling the blast pressure during the charge. The speed of the gaseous current must be so great that the flame which rushes out of the converter maintains a clear and well defined outline and a steady position. If the flame begins to waver or oscillate laterally, it is always considered as a sign of insufficient blast pressure. An excess of blast pressure is attended with violent and very voluminous eruptions of slag and metal from the vessel, and it can be easily remedied by allowing a portion of the blast to escape from the main pipe. This is preferable to throttling, because it does not throw any sudden back pressure upon the blowing engine, and allows the latter to keep up its speed with uniformity. An accident which occasionally happens in blowing a Bessemer charge is the cracking of a tuyere. If this takes place during the earlier part of the process the vessel may be safely turned down, and the metal will remain fluid while a fresh tuyere is inserted. If the accident happens during the later stage of decarburization the danger of setting or solidifying is much greater, but there is still a possibility left to to save the charge by skilful management. The vessel is turned down for a second, and this allows the liquid steel which fills the crevices of the cracked tuyere to solidify, and choke the escape passage or leak. The vessel is then tight for another minute or half of a minute, after which time the process must be repeated. It is possible to repeat such an operation three of four times, and the few fractions of minutes thus gained may be sufficient for completing conversion of the charge.*

The most important and at the same time the most difficult part in the management of a Bessemer charge, is the determination of the precise moment when the charge is completed, and where the vessel must be turned down for receiving the final dose of spiegeleisen. When the flame is clearly visible at the end of the charge, there is no difficulty in recognising a sudden change of its color and appearance after a short practice; but some qualities of iron evolve such masses of dense smoke of red, white, brown, or yellow color, that the flame is completely covered, and the changes in it are very difficult to observe. The spectroscope, the slag-test, and similar other contrivances, are then brought into requisition with more or less success; but fortunately these inconvenient kinds of iron form the exception, and not the rule, amongst the pig iron which is applicable to the Bessemer process.*

The purpose and intention of the final addition of spiegeleisen is to remove the surplus oxygen from the metal which may have remained in it after complete decarburization. The elements by which we can remove oxygen from iron are carbon, silicon, and manganese. Of these silicon has the important advantage that it forms no gaseous combination with oxygen, and therefore causes no ebullition in the ladle and in the moulds. Against this there is the great danger of overcharging the steel with the silicon, which may be added to it in excess of the precise quantity required for the removal of the oxygen. The consequence of such an overcharge would be hardness, brittleness, and want of elasticity in the steel produced. Carbon and manganese form gaseous combinations with oxygen at the high temperature existing in the converter; the ebullition in the ladle and moulds is therefore not easily avoided when these elements are used for removing the oxygen, but the surplus of carbon left gives

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* The giving way of the lining around a tuyere or the burning away of a tuyere, are of more frequent occurrence. We have seen a four ton vessel turned down 55 minutes within five minutes of the completion of the blowing, and the charge saved, but of course very cold, and sculling in the vessel and ladle. We have turned down nine times within fifteen minutes, and saved the charge. If the metal runs through a small hole, and sufficient *time* is taken to chill it in the hole, a charge may be generally saved. But the forcing up of a wet bottom by the steam formed in it, and any large hole in a thin part of the lining, are remediless cases. The metal in the converter must then be cast into pigs, if possible, as if partially blown it will stick to and destroy the cast iron ingot moulds.—Ed. Van Nostrand's Magazine.

* But one of some hundred kinds of pig iron with which we have experimented in this country, has given an uncertain indication of decarburization.—Ed. Van Nostrand's Magazine.

the required hardness to the steel, and any surplus of manganese remaining in the steel is comparatively harmless as regards the quality of the product. When silicon is present the manganese is less liable to cause ebullition, since it can form a liquid slag, or silicate of manganese. For these reasons the final addition to the Bessemer charge should contain the three elements, carbon, silicon, and manganese. There should be a surplus of manganese to allow for the uncertainties regarding the quantity of oxygen left in each charge; there should be no more silicon than is required to form a slag with the greater portion of the oxide of manganese; and there should be no more carbon than is needed for finally carburizing the charge of steel. The natural spiegeleisen, as a rule, is too poor in manganese, and too rich in carbon to produce this effect, and when steel is made by its application it is difficult to produce a very soft quality. Mr. Henderson's ferro-manganese, which contains from 20 to 30 per cent. of manganese combined with 5 per cent. of carbon and a small quantity of silicon, is a substance of much greater value for the production of the highest qualities of soft steel; and the mode of manufacturing such artificial alloys affords a possiblity of bringing the relative quantities of the elements to almost any desired proportion.

The spiegeleisen should not be kept in the furnace for any length of time, as it loses its manganese and silicon by oxidation. It should run into the converter with great speed, so as to enter into the liquid charge with a certain momentum. This prevents its collecting upon the surface of the decarburized iron, which has a greater specific gravity than spiegeleisen or ferro-manganese. It is not necessary to turn up the converter a second time after the final addition, since an immediate reaction takes place, and a large white flame rushes out of the converter although the blast is entirely shut off. The liquid steel is then immediately poured into the ingot moulds. Only in the exceptional case, when there in no flame visible at the converter mouth after the addition of manganese, the vessel must be turned up a second time, and the blast passed through it for a few seconds. This is done because the absence of a vivid reaction indicates that the charge had not been blown long enough at first, so that there was no surplus oxygen left in it, and the additional time of blowing is required for removing the surplus of deoxidizing elements added at the end of the charge.

CHEAPER RAILWAYS AND WORKING.

The British newspapers, professional and commercial, are discussing this subject very earnestly. It is important to us in America, however, that we should not be led astray by names. The cheap and light railways advocated by Englishmen, are by no means to be deprived of the best known systems of drainage, ballasting, rails, rail jointing, rolling stock and power. Indeed, it is proposed to increase the weight of rails, and a great economy is expected from articulating engines and trains at a considerable extra cost. British engineers propose to cheapen railway construction chiefly by *avoiding heavy earthworks and costly works of art, and by filling the trains.* It is proposed to go over and around hills rather than through them. The cost of steam power on gradients and of wear and tear on curves, is less than the interest on the works necessary to avoid gradients and curves, within reasonable limits. The American system may be followed to advantage, in this particular.

But in respect of stations, the American system is equally wrong—in the other direction. Our traveling public is incommoded, disgusted and led to avoid railways rather than accommodated and encouraged to travel by them. A railway station need not be a palace, but Paddington stations at West Philadelphia, Albany and Baltimore, for instance, and a St. Pancras in the upper part of New York, with overhead or underground downtown branches, would pay better than the cramped disagreeable and unsafe sheds that now incommode the great traffic of these localities. In the matter of carrying tons of non-paying load to pounds of paying load, the English system of compartments, and guards paid to keep them empty,* is as bad as possible. Now that our own system of one fare and one class thoughout is modified by the introduction of sleeping berths, sitting-rooms and other accommodations specially (and roundly) paid for, it may well be studied abroad. The transportation of non-paying load however, is a very serious evil everywhere; there is no really good practice to copy, and the whole department requires reorganizing on a radically new plan. The following considerations on this subject

* English express trains are very heavy, very fast, and very frequent, and they are rarely well filled. A few shillings to the guards and porters will purchase accommodations that cost the railway company many times that amount.

are compiled from various numbers of "Engineering" and from the "Railway News":

Railway transport in itself is a very profitable business, yielding from 50 to 60 per cent. of gross receipts in the shape of profits. These handsome profits have, however, been rarely if ever realized for the benefit of those who have invested in the undertakings, for previous to the distribution taking place a host of parasites have to be provided for. The seven lean kine which eat up so large a share of the profits of railways are: Unnecessary expenditure in preliminary and parliamentary proceedings; excessive payments for land; excessive cost of construction; unremunerative expenditure upon branches; duplicate lines and improvements upon original line by short cuts and otherwise; cost of financing and jobbery connected with formation of company, issues of securities, and construction contracts; and accumulations against capital account of dividends paid, but not fairly earned. By way of illustration in a line now being constructed by the Midland Company, running parallel with a line belonging to the Great Western, there is no difference whatever in the formation or the nature of the work; but the same length of line which cost the Great Western Company one million is now being constructed by contractors for two hundred thousand pounds, or just one fifth! In the case of the Brighton Company, the committee of investigation specified twelve branches which did not pay working expenses, much less any return for interest on capital.

The interests of a small community of shareholders and bondholders, who have wasted their money in a railway are not to be considered against those of many millions of people who are made to pay for the waste. Were every corn-mill and every bakery in the kingdom built of such costly materials, and of such needless dimensions and such elaborate architecture, as to have cost twice what it ought, this would be no excuse to the public for demanding of them twice the present price of bread. For all the great necessaries of life—food, drink, clothing, firing, lighting, the means of transport, etc., the necessary cost of which is known—the public will demand and ultimately enforce the supply at that cost, including a fair profit upon only the *necessary* capital employed.

It has been too long the habit to regard the mere cost of traction as the chief element of railway expenditure, whereas *the* great item of expense is interest upon capital—not of course that interest or dividend is always paid, although it is not the less chargeable in default of payment. To pay the interest on the whole cost of the present lines requires a charge in the way of fares and freights at least twice greater than the present total working expenses. Of the latter, locomotive power, repairs and renewals of rolling stock, and maintenance of way, which alone are influenced by gradients and curves, do not form much more than one-half, the remainder going in management, train and station service, rates, taxes, Government duty, etc. In other words, nearly or quite three-fourths of what the public now pay to the railways is absorbed in expenses and in payments upon capital not in themselves influenced by the steepness of gradients or the sharpness of curves. Again, taking the expenses which are so influenced, it is certain that very considerably steeper gradients and shorter curves may be introduced, here and there, to save costly works, without increasing the cost of locomotive power and the outlay for wear and tear by more than a very moderate percentage. If this increase did not, as it hardly would, exceed five per cent., and the new line cost but half as much per mile as the old, then for every pound now paid by the passenger, very nearly five shillings would be saved to him while paying the same rate per cent. of profit upon the railway capital as now. If, by the outlay of £1,000, a clear saving of £50 can be effected yearly in working expenses, the outlay is justifiable, but if £100,000 are spent to obtain theoretically favorable gradients or curves which do not really save £1,000 yearly in working expenses the outlay is a wasteful one If this extra outlay be made upon a single mile of line, as upon a costly viaduct, or a tunnel, the interest upon it at five per cent. is 1,200,000 pence per annum, equal to £13 14s. per day, and equal to nearly 7s. per train for each of forty trains running daily over that mile for 365 days in the year. Taking the number of trains at a more reasonable figure, say, twenty daily in both directions, it is evident enough that the cost of working a comparatively steep incline half a mile long, the adoption of which would avoid the necessity for a costly tunnel or viaduct, could be nothing like 14s. per train above and beyond the necessary cost of working a level.

SEWAGE.

OLD AND NEW SYSTEMS—REQUIREMENTS, CAPACITY AND VENTILATION OF SEWERS — APPLICATION OF SEWAGE TO AGRICULTURE—PURIFICATION OF SEWAGE.

Compiled from M. Mille's account of the Paris Sewage, Chief Engineer Hermany's report on Memphis Water Works, "The Engineer," "The Builder," The report of Messrs. Bateman and Bazalgette on the Glasgow Sewage, &c.

The complete removal of sewage, not only from towns, but from the waters and even from the vicinity of large towns, is one of the most vital and urgent questions of the day. The health of millions and the lives of thousands of human beings depends upon it. In the older towns of Europe, it is perhaps the foremost engineering as well as sanitary problem. In the larger American towns, especially those that are not traversed or surrounded by great volumes of natural tides or currents to dissipate and dilute the sewage, the necessity of disposing of it by artificial means is felt and acknowledged. But unlike the greater number of works for the public protection, such as fortifications, docks, fire departments, &c., which return no revenue, sewage works properly constructed, are *commercial and manufacturing investments*, as much so as the importation of guano or the preparation of the Charleston phosphates. Besides being indispensable to the healthfulness of all towns, and even the habitableness of some, sewage works may be made to pay directly, in the wonderfully increased productiveness of lands to which the refuse matter is applied. Even in cities like New York, this view of the case cannot long be ignored. Although New York is surrounded by a volume of water that dilutes and appears to dispose of its sewage, great banks of this material are already found in all its slips and beneath its waters—foul banks that are even now reservoirs of disease, and will one day spread pestilence along its shores, instead of directly contributing to its health and wealth, by cheapening and so bettering the food of its people.

Ancient Systems.—In ancient Rome the *cloaca maxima* carried the whole refuse liquids of the city into the Tiber, as was the case with the Thames not long since. The Arabs introduced irrigation into Europe, and the practice spread gradually along the western coast of the Mediterranean. In the thirteenth century, at the time of the Christian conquest, the plain of Valence was watered by seven branches of the Xucar, and in the town the sewage of the houses was conveyed through earthen pipes, or brick conduits, into open sewers. As the population increased infection became serious, and the conqueror, Don Jayne d'Aragon, ordered that the waters of a canal called the Cuart should be made to run into the sewers for two hours in every twenty-four, to carry off the filth. Near the walls of the town the inhabitants drew out the mud, and, after drying it in the sun, used it as manure, while those who lived further down dammed the stream, and forced the water to pass into ditches in their own fields. The result was that the portion of the Huerta de Valence which lay nearest to the canal became a perfect marvel of fruitfulness, and remains so to the present day. In Milan, in the middle ages, the sewage of the town, and the refuse of the woolen works, were received in open sewers, which surrounded the town, and the contents were carried to the river Po by means of an old bed called the Vettabia, which traversed the lands of the Abbey of Clairvaux, belonging to the monks of Citeau. Tradition says that it was Saint Bernard himself who conceived the idea of feeding the abbey lands with the foul waters of this stream, and that the result of his experiment was marvellous. In the fifteenth century Francois Sfforza cut the canal of the Mortesana, and appropriated the water of the Adda for the cleaning of the sewers of Milan. The irrigation was then extended over between three and four thousand acres; and this, with the great industry of the people of Lombardy, created the *marcites*—meadows which yielded in some cases as many as eight crops in the year, supported more than three milch cows on every hectare (two-and-a-half acres), and gave rise to the famous manufacturo of Parmesan cheese.

Modern Systems.—In London and some other cities, the sewers were originally intended to carry off rain water only. Up to the year 1815 it was penal to discharge sewage or other offensive matter into the sewers; cess-pools were regarded as the proper receptacles for house drainage. But as the population increased, tho subsoil became thickly studded with cess-pools, improved household appliances were introduced, overflow drains from the cess-pools to the sewers were constructed; thus the sewers became polluted, and covered brick channels were necessarily substituted for existing open streams. In the year 1847 the first act was obtained, making it compulsory to drain houses into sewers. The present English solution of the problem, as developed in their general systems of town drainage, has been to construct underground, generally along the center lines of streets and alleys traversing the districts to be relieved, conduits of masonry; or to lay stone-ware pipes. Into these all house and factory refuse, and all cast-off matter which can be floated, are conducted by means of branch drains and street gulleys, and by the aid of an ample public water supply and occasional rainfalls, through these conduits into natural watercourses, to be diluted so far as to be inoffensive. This manner of disposing of city sewage is called the *water-carriage* system. It is, with some exceptions, the general practice in England; and, so far as sewage works have been designed and constructed in the United States, the universal practice.

In cases where there is insufficient fall from the street sewers to the place of deposit, pumping is largely resorted to; the whole of the vast low level drainage of London, amounting to more than 83 square miles, is thus disposed of. The cities of Liverpool, of Leamington, the proposed immense drainage of Glasgow, besides numerous great cities on the continent, like Berlin and Hamburgh, have works conceived and executed with the same view. Similar works are proposed for some of the American cities; Troy among others.

The mixing of fecal matter with water, and disposing of it through the sewers, finds, however, little favor on the continent of Europe, and is obliged to encounter much opposition from some of the ablest scientists and engineers in England. It is condemned on account of polluting the natural watercourses and depriving agriculture of a valuable fertilizer. The tides of the ocean, even, are proved inadequate to remove the sewage cast into it. The expectations respecting the transporting action of the tide have proved completety delusive, as the blackened foreshores of Erith and Greenhithe, and other places on the Thames, can testify. Any town that discharges its sewage into the sea, or gets rid of it, as the usual term is, by this method, will find that there is a vast difference between a simple transference and a complete removal. Absorption, not solution nor dilution, is the only manner in which to effect the complete removal of sewage, and that is a faculty enjoyed in the fullest degree only by the soil and the wonderful assimilating action of plants. To avoid the nuisance and the waste of throwing the sewage into streams or the sea, the fertilizing matter must either be kept out of the sewers altogether, and a different system of collecting and transporting it devised, or else it must be collected at the outflow point of the system. It may in either case be deodorized, should that process prove successful. The main drainage of London is intended to float or propel by running water, all the sewage of the town, to a point far below the town, where the fertilizing matter will be collected in solid form. The Paris system is the same, and has been frequently described. During the last twenty years, a complete system of drainage, terminating in a main sewer with a flow of from three feet to six feet per second has been attained, and the authorities have finally determined that the Seine should be cleared of the pollutions of the town. In Paris, however, the use of cess-pools continues to a great extent, and the foul matter of the houses is not in all cases passed into the sewers. But the cesspools are properly cared for and cleaned. But this is an expensive process. Over 2,000 tons per night are removed from private houses. Steam pumps convey over 500,000 tons per year to the basins at Bondy, six miles from Paris, and 50,000 tons of half-solid matter which the pumps will not act upon, is removed in casks. At Bondy the night-soil is transformed into sulphate of ammonia, and into *poudrette*, which is the solid deposit left in the basins, dried and sifted. But this method of preparation is very rude, and nineteen-twentieths of the useful matter are said to be lost.

In many American towns, however, the only system that can be *afforded* at present, is simply to get the sewage out of the town, by the comparatively inexpensive method of water carriage in the sewers. In the Memphis region, for instance, where this subject has come up for settlement, the land for agricultural purposes is too cheap, abundant, and fertile, and the scope of agriculture too limited to permit the expensive application of fecal matter as manure; and the further pollution of the Mississippi by the addition of the sewage from another city is a contingency altogether too remote for serious consideration.

Requirements and Capacity of Sewage Works.—To what extent any system of drainage should be a modification or a suspersedure of the natural drainage, depends on the topography, area, natural streams of running water, rainfall, and population which obtain in different districts or cities. The best existing systems of artificial drainage give evidence of having arrived at whatever degree of perfection they now possess by passing successively through the stages of improvement, and at least partial supersedure of the originally existing natural drainage. In some of the most densely populated cities the only traces of a former natural drainage are the lines of the main outfalls, which, to a greater or less degree, coincide with the natural lines of rain-water outfalls. Therefore, it is evident that the tendency of all systems of artificial drainage is inevitably in the direction of the *total supersedure of the natural drainage.*

The first question to be solved is the size of the sewers; to determine which, three elements are indispensable; the areas to be drained, the inclination of the sewers, and the maximum quantity of sewage and rain-water discharged in a given time from said areas. The first two of these elements only are known; the latter remains to be determined, and is composed, in cities enjoying a public water supply, in connection with a general use of modern house conveniences, of the *refuse water* holding the solid matter in suspension, and the *rainfall discharge.* The refuse water is found, in densely populated cities, to vary but inappreciably from the water supply in bulk; one-half of which, according to observations on the London sewers, finds its way to the sewers in six hours, and the other half in the eighteen remaining hours out of the twenty-four. Then, taking the water supply at 60 gallons or 8.0214 cubic feet per 24 hours *per capita*, and the resulting sewage as the same in bulk, one-half of which being discharged in six hours, and rating the ultimate population at seventy-eight persons to the acre, equivalent to fifty thousand per square mile, there will result 0.0144 cubic feet as the sewage per acre per second (equivalent to a rainfall 0.0143 in. in depth per hour), rated according to population and water supply. The rainfall discharge depends upon the depth of rain falling in a given time, and the condition of the surface upon which it falls, whether dry, wet, frozen, paved, built over, or cultivated; modified by the declivity of the slopes along which the discharge takes place. Mr. Bazalgette's paper on the London Main Drainage, says: From careful observations of the quantity of rain falling on the metropolis, within short periods of time, it has been ascertained that there are about 155 days per annum upon which rain falls; of these there are only about 25 upon which the quantity amounts to $\frac{1}{4}$ of an inch in depth in 24 hours, or the 0.01 part of an inch per hour if spread over an entire day. Of such rain-falls a large portion is evaporated or absorbed, and either does not pass through the sewers, or does not reach them until long after the rain has ceased. In the report of Messrs. Bidder, Hawksley and Bazalgette, in 1858, on the subject, it is stated that continuous observations, show that the quantity of rain which flowed off by the sewers was, in all, cases, much less than the quantity which fell on the ground; and although the variations of atmospheric phenomena are far too great to allow any philosophical proportions to be established between the rainfall and the sewer-flow, yet they feel warranted in concluding, as a rule of averages, that $\frac{1}{4}$ of an inch of rainfall will not contribute more than $\frac{1}{8}$ of an inch to the sewers, nor a fall of 0.4 of an inch more than $\frac{1}{4}$ of an inch. Indeed, they have observed rainfalls of very sensible amounts failing to contribute any distinguishable quantity to the sewers. But there are in almost every year exceptional cases of heavy and violent rain-storms, and these have measured one inch and sometimes even two inches in an hour.

As to the size of sewers, in Great Britain and on the continent, experience has demonstrated that improper substances admitted into sewers will obstruct them, no matter what may be their dimensions, and must be removed by manual labor. To effectually meet this evil, the earlier practice was to make all the sewers large enough to conveniently admit men, to pass through them and remove matter which should never have found its way into them. Sewers constructed upon this plan are costly to build and keep clean; they induce the admission of refuse which cannot be removed by water, but which could generally be carted away much more economically from the surface at the points of accumulation than by being first unwisely forced into sewers, thence exhumed by the tedious and life-destructive labor of the sewer-scavenger, and then carted away; calling into requisition a "description of labor which it is improper for human beings to perform, and which ought to be forbidden, as being false in principle, and belonging to a low state of art, and as being ignorant or interested excuses for the avoidance of the trouble and expense of practicable and efficient substitutes." As sanitary measures, large sewers are very objectionable. The constant accumulation of foul matter during the dry season of each year, when the flow of sewage does not keep the main sewers clean, would convert them into elongated cess-pools, and thus originate or aid in prolonging epidemics to a fearful extent. To keep sewers of this magnitude clean, by flushing them with water from the public water supply, would involve an expense for elevating water for this purpose alone, which at present cannot be estimated; except in very flat districts, it appears preferable to provide for the removal of excessive rainfalls, by natural drainage, or by surface drainage, and to provide only for the ordinary quantity in the underground system. The main sewers of the Memphis works are designed, when running full, to discharge three times the maximum quantity of sewage independent of rain-water, or three times 0.0144 cubic feet per acre per second, as heretofore determined; *i. e.*, the sewers are made sufficiently large to carry into the river sewage equal in volume to a discharge of one inch of rain in 24 hours. The minimum inclination of the main sewers is to be 3.168 feet per mile, which, in the case of a three-feet sewer, when running half full, will produce a velocity of current equal to 2.6 feet per second, or 1.4 miles per hour, calculated by Prony's formula. The actual velocity, however, in a sewer of this size and inclination, when half filled, is greater from the fact that at every junction with its branches (provided the junctions are properly made) the volume of sewage flowing in the main sewer receives an increment of velocity arising from the greater inclination of the branch sewers.

In all main sewers, however, there will be accumulations of solid matter, and to provide for its decent and economical removal, catch basins are, in the best practice, built under the line of the curb-stones, at the street corners where the surface water from the gutters flows into the sewers. They have trapped connections with the sewers, and movable cast iron covers. At the junctions of the catch-basin discharges with the branch sewers, and at all changes in the alignments of sewers there are also man-holes, located in the center of the streets, and fitted with perforated covers, to facilitate inspection and the removal of deposits, also to ventilate the sewers. It is also well to place intermediate manholes, every 100 feet, to determine the location of deposits. These may be covered by the pavement, to save cost, as they need not often be uncovered.

Ventilation of Sewers.—Gas evolved by decomposing organic matter in sewers, is always dangerous to health. In small quantities it poisons the blood and produces typhoid and those other diseases commonly termed *zymotic*. In a perfectly undiluted state the gas would cause instant death. In his evidence before the Select Committee on the Sewage of Towns, Dr. R. A. Smith states that sewage is oxidised even before it leaves the town, and that poisonous gases, are evolved in large quantities. Whenever the temperature rises to about 54°, which is the usual temperature of sewers, oxidation is intensely rapid. The gases are generally as follows:

Carbonic acid	95.0
Nitrogen	2.6
Sulphuretted hydrogen	2.0
Carbonic oxide, hydrogen, and carburetted hydrogen	0.4
	100.0

The motion of the liquids constantly exposes fresh matter to the influence of the air, and the solid matter deposited in the sewers or adhering to the sides, being in an advanced state of decomposition, the exhalations are of the most deadly character.

What becomes of these gases? It has been supposed by some that the carbonic acid gas being heavier than air, finds its way to the outfall and is dissipated in the air; this is clearly an error; the law of gaseous diffusion militates against this theory. The constantly accumulating gas is soon rendered highly concentrated by the temperature in the sewers, and as soon as the pressure of this exceeds the hydrostatic pressure of the water in the traps it escapes. The bubbling noise not uncommonly heard in closets and sink traps is caused by gas escaping in this way; moreover, sewer gases are extremely soluble; water readily absorbs more than its own volume of carbonic acid gas, consequently the water in the traps rapidly become highly charged with sewer emanations, which cause it to putrefy and evolve most dangerous gases into the apartment.

The ventilation of sewers by grates opening into the streets—the delivery of these gases into the very midst of the street throngs and into the doors and windows of houses, is hardly a remedy of the evil. To disinfect sewer gases before they can reach the street, vegetable charcoal spread lightly on a perforated tray or basket has been fixed in connection with the man-holes. When dry it effectually purifies the gases, but as it absorbs water rapidly it requires to be renewed frequently. The steam and damp vapors from the sewers will in short time render it useless. Elaborate and expensive ventilating chambers have been erected on this plan in West Ham and some other places. The process is theoretically correct, but its practical value is very doubtful, for the reasons stated. It has been proposed to connect the sewers with factory or other chimneys, so that the gases may be discharged into the air at a great elevation. There is reason to believe that this method may be made successful. The expense of building special chimneys and keeping up a furnace would be too great to be entertained, unless all other reasonable schemes result in failure; but if a factory chimney exists near the summit of a sewer, a connection can be made with very little expense. A small central chimney would be useful only for a short range; the air would be drawn with great force into the sewer, through the traps in the neighborhood; while the sewers at a distance would not be affected in the slightest degree. Rain-water spouts have been used in some instances; but the objections to this system are numerous. During heavy storms, when the sewers are being rapidly filled with water and when some outlet is specially required, the spouts are required for their legitimate function; besides which, leaves and birds' nests cause frequent obstruction. The gases would, moreover, be discharged into the immediate neighborhood of bedroom-windows.

The corporation of Liverpool has recently incurred great expense in the endeavor to solve this important problem. Over 1,000 iron shafts, about eight in. in diameter, with revolving tops, have been fixed in corners or recesses. These shafts are joined to the sewers in convenient places, and are also carried far above any windows. A great reduction in the rate of mortality has followed their adoption.

Application of Sewage to Agriculture.—The following are recent facts regarding the experiments on the application of sewage to agriculture, at Paris. Two methods, which may be called the agricultural and the chemical, were to be tried simultaneously. A laboratory was also fitted up for the daily analysis of the sewage water. Near the mouth of the great sewer at Asnières, a centrifugal pump capable of raising 500 tons of liquid per day, was erected and a plot of ground, about four acres in extent, was laid out. The sewage water, merely passes along the small channels which bound the beds, in which various kinds of plants are cultivated, but especially roots; the water filters through the soil, feeds the plants and leaves in the channels a valuable deposit, which is incorporated with the soil and which applied to bare land in winter produces the same effect as good manure, and prepares the soil for spring crops. No other kind of manure is ever used at the Clichy establishment. The products are of excellent quality. From November, 1867, to July, 1868, 26,000 tons of sewage water have been applied to the soil there; the water is therefore purified naturally, and at the same time acquires a commercial value which is estimated at about one halfpenny per ton.

The report of Messrs. Bateman and Bazalgette on the sewage of Glasgow says: The application of sewage to land has not only resulted in an amazing increase of its productiveness, but, where the application is properly conducted and the ground suitable in character, the sewage is deprived of all objectionable smell and appearance, and may then be safely permitted to flow into such a river as the Clyde or into the sea on any part of the coast. Probably the most notable instance of the successful agricultural application of the sewage in this way, is over the Craigentinny meadows near Edinburgh, where the land has been made to produce 40, 50 and 60 tons of grass per acre, per annum, which is generally sold to persons, who cart and carry it away themselves, for prices generally exceeding £30 per acre, and in some instances upwards of £40. There, however, the mode of application has been defective—the ground has been overdosed with sewage, and its objectionable qualities have not, therefore, in a sanitary point of view, been wholly removed. At Croydon, the purification of the sewage of that town, by passing over grass lands in the immediate neighborhood, has been so successful that people residing close up to the sewage-irrigated land do not complain of any nuisance; and so entirely devoid of color, smell, or taste is the sewage, after having passed over the ground, that on comparing a bottle of it with a bottle of water from Loch Katrine, without knowing in which bottle the respective waters were contained, one of us actually selected the Croydon sewage water as being that which he believed was Loch Katrine water. Similar results have attended its application at Rugby, Carlisle, Barking, and other places; and there can therefore be no doubt whatever that foul sewage, after being properly and sufficiently passed over suitable land, and applied to suitable crops, may be wholly deprived of its offensive character. The land which it appears is best adapted for effecting this purification, is well drained friable clay or sandy loam, free enough to absorb the sewage and gradually allow it to filter through, but not so free or open as to allow it to pass through too quickly. Sands and gravels, too, appear to produce this disinfecting result, and all crops are apparently suited for the reception of sewage, though that to which it can be most readily applied, and which, perhaps, in its turn produces the most beneficial result in its purification of the sewage, is grass land, especially rye grass, cut green and carted from the ground.

The application of sewage to agriculture has met with two serious drawbacks in England. At first the local authorities and the farmers were at open war, and everything was carried on under compulsion. No sooner did the local boards discontinue the pollution of the natural water-courses, and apply the fecal contamination to the land, than it became necessary to endow them with power for the compulsory purchase of land needed, as no farmer would willingly permit them to use his fields for the purpose. As the prejudiced mind of the agriculturist became more enlightened by the undoubted success and value of sewage irrigation, it began to entertain another grave error, viz: that the only difference between the present and future methods of manuring land consists in the substitution of one fertilizer for another. This is a serious mistake. The one is a simple and primitive mode, capable of design and execution by any common farm laborers; the other is an accurately and carefully planned project, requiring, from first to last, a high degree of professional skill, and technical knowledge and ability. Thus it is that in the few instances where the agriculturist has been his own engineer, his attempted utilization of sewage has eventuated a miserable failure, greatly to his own surprise and chagrin, and also to the detriment of the principle which he tried to put into execution. Regarding sewage irrigation as applicable to every description of crop, it must, in every instance, necessitate some preliminary preparation, or surface formation of the land, which it is intended to irrigate. This circumstance mainly contributed to the restriction of sewage irrigation principally to grass crops, which admit of a very reckless and unscientific distribution of the fertilizing fluid. The case is otherwise where cereal crops are concerned. According to the physical contour of the land, so will the preparation of its surface be more or less expensive. As the ground must be prepared for a railway before the permanent way can be laid, so is a similar operation, in a minor degree necessary to insure the proper and remunerative disposal of sewage.

Artificial Purification of Sewage.—Various schemes for this purpose have been tried and many others are on trial and proposed. The Paris experiments before referred to, are as follows: A solution of sulphate of alumina is made in the proportions of two hundred weight of the alum to 1000 litres of water, and two litres of this solution were used for every ton of sewage to be purified. The price of the alum delivered at Clichy amounted to eleven francs per 100 kilos., about 4s. 6d. per hundredweight, making the expense of purifying a ton of sewage something less than one farthing. Lately a pure solution of the sulphate has been obtained; one pound is mixed with two or three times its own volume of water, for every ton of sewage to be purified. The solution costs about one shilling per hundredweight, and the expense of purification thus only amounts to one centime, or less than the tenth of a penny. The mode of carrying on the operation of clarification is very simple; the sewage water, after having received its dose of solution, is admitted into the basins, which it traverses slowly, while the particles in suspension are deposited as in the operation of fining; the water flowing out of the basin is so pure that it may be turned into the river. The basins are emptied about once in six weeks, and their deposit is removed without difficulty. The clarification occupies less than ten hours; the water, black on entering, becomes of a greenish tinge as soon as the solution of alum has mixed with it, and passes off at the further end of the basin pure. The manure left at the bottom dries readily when the layer is not much more than four inches thick. It passes from black to brown, cracks, and assumes much the look of cork. Very little smell is given off either from the basins or the irrigating gutters; the gaseous matters are almost immediately consumed by the air and light. The precipitated matter contains from fourteen pounds to sixteen pounds of nitrogen per ton. More than 50,000 tons sewage water have been clarified in twelve months, producing about 100 tons of precipitate. The composition and nature of this precipitate place it exactly on a footing in all respects with the refuse of mud swept from the public streets. Side by side with the practical experiments, careful scientific examinations are pursued in the laboratory. As already stated, a ton of the sewage water contains about six pounds of various foreign matters; azote, phosphoric acid, alkalies, organic and earthy matters. The precipitate contains half the azote, all the phosphoric acid, and most of the organic and earthy matters, while the clarified water holds in solution the other half of the azote, and all the alkaline matters. From these data the values of sewage water are ascertained to be as follows: A penny a ton for the fluid as it exists in the sewer collector, and the precipitate about eighteen shillings per ton; the total quantity poured into the Seine daily averages 200 tons, so that the value of the sewage water would amount to about £300,000 per annum.

The A. B. C. process of Mr. Sillar about which so much is said in the English papers, is named from the initials of its three principal ingredients, animal charcoal, blood, and clay. When this compound is suspended in water and added to the sewage, a precipitate in large flakes is immediately produced; the supernatant liquor is drawn off into a tank and a small quantity of perchloride of iron solution added. The iron compound serves to remove the sulphuretted hydrogen. It has been found convenient to add a certain proportion of alum, since the process is thereby accelerated. This process was tried at Leicester, where the lime process had previously been used. Dr. Frankland's report upon it says: The purification of sewage may be conveniently considered under two heads—1st, clarification, or the removal of suspended matters, so as to make the resulting liquid more or less clear and transparent; and 2d, removal of matters in solution. The suspended matters contained in sewage are well known to undergo rapid putrefaction and to become very offensive; consequently their removal either by filtration or chemical treatment constitutes in itself an important amelioration in sewage. But the liquid so clarified contains in solution much nitrogeneous organic matter, which is prone to become putrid even when mixed with a considerable volume of river water.

In conclusion, the results of the experiments may be thus summarized:

"1. The Sillar and lime processes remove to a great and nearly equal extent the suspended matters contained in sewage.

"2. Sillar's process increases the amount of dissolved solid impurity in sewage, but reduces the quantity of putrescible organic matter. The lime process reduces both the amount of dissolved solid impurity and the quantity of putrescible organic matter; the reduction of the last being about the same as that effected by Sillar's process, viz: rather more than one-half.

"3. To the manufacturer of solid manure from sewage, Sillar's process is greatly superior to the method of treatment by lime, although it fails to extract from the liquid more than a very small fraction of its valuable constituents."

Advantages of Irrigation over Deodorization.—The report of Dr. Frankland further concludes: "Like all chemical methods hitherto invented, both processes fail in purifying sewage to such an extent as to render it admissible into running water. It still remains a fact that no chemical process is known which even remotely approaches irrigation in its efficiency as a purifier of sewage."

The report of Messrs. Bateman and Bazalgette, before quoted, says: "All attempts at deodorization or precipitation on a large scale have hitherto so completely failed, either commercially or chemically, that, in our opinion, the idea of correcting the evil by any such process need not be regarded; and hence it becomes necessary, either to turn the sewage in its natural condition into the sea at some point sufficiently distant from populous places or districts, or, by allowing it to pass over a sufficient area of suitable lands to clear it of all objectional character, and to render it so pure that it may without fear of creating a nuisance be turned into the river or the sea." The "Engineer" in discussing this subject, concludes that every discription of disinfecting and deodorizing nostrum has been allowed a fair trial, and the practical result has been, without exception, a complete failure. They all come to grief in one of two ways, and generally in both. They all have failed to convert the solid or semi-solid residue into a marketable manure, which will sell, speaking broadly, for anything. A few of them have been successful in purifying the sewage so far that the liquid might be run into a stream, where the owners were not over particular. This is nothing more than a feat that any decently educated chemist could accomplish. The only real and efficient purifier of sewage is the soil, and no chemical process has been yet discovered which will effect this object and at the same time retain or fix the valuable fertilizing ingredients. From the recent report of the results obtained at Barking Farm, it will be perceived that there is no longer any doubt upon the subject. In spite of the poverty of the soil at Barking, the sewage has been able to confer upon it all the fecundity belonging to the richest lands. Splendid cereal crops, fields of bulbs and roots, have resulted from the application and the thoroughly efficient manner in which the farming operations are conducted.

THE SUEZ CANAL.

PRESENT STATE — PARTICULARS — USEFULNESS—ENGLISH OPINIONS.

In a communication to Paris, M. de Lesseps states that a small schooner, "La Levrette," has recently passed through the Suez Canal, and that six vessels belonging to the Egyptian fleet are about to pass from one sea to the other. It now may be safely said that this canal is opened for vessels of small tonnage; and in six months' time ships of from 2,000 to 3,000 tons burden will be able to make use of it.

The Suez Canal is about 90 miles long, and will be 328 feet wide at the water line, 74 feet at the bottom and 26 feet deep. The slopes under water are very flat—five to one. The excavation will have required the removal of 96,000,000 yards of earth. The work presents no engineering difficulty except magnitude. The cost is estimated at 60,000,000 to 75,000,000 dollars gold.

As to the usefulness of the canal, the Dutch Commission report that it will help sailing vessels bound beyond the Indian Ocean very little—ten or fifteen days in 100; but that it will save steamers fifteen to seventeen days in a voyage of 60 to 70 days. The rate of toll is not decided, and it is stated that steamers will not be allowed to use their own propellers, but will be towed by some means that will not wash the banks. The English papers are "calculating" that it will hardly pay.

An American scientific writer, sojourning in London, ten years ago, prepared an elaborate article favorable to the Suez Canal. The article was thrown out by the proprietor of the journal to which it was contributed. But, said the writer, "the project must succeed—there are no insurmountable difficulties." To which the proprietor replied to this effect, and his reply sums up the British opinion of the period: "The Suez Canal is not recognized as a proper subject for professional discussion in England. Englishmen have determined that it should not succeed." But British opinion is subject to change on this as on other subjects, and the "Practical Mechanic's Journal" now makes this handsome acknowledgement.

The Suez Canal—after years of labor and perseverance againt every obstacle and discouragement, enough alone to immortalize the names of Lesseps and those who have, like his able contractors Lavalle and Borell, stood staunchly by him through every difficulty—at last begins to prove itself to the world at large, and even to the most incredulous eye, as about at an early period to be accomplished. In fact, in some sense, it is so already. The Sweet Water Canal has already conferred great agricultural benefits upon the country through which it passes, and must prove hereafter a source of uncountable riches to Egypt, and of great revenue to the canal company. The English engineer who showed himself, as regards this Suez Canal question, the only competent one —for Mr. John Hawkshaw, in his able report, boldly stated that it was not only practicable but easy to construct, and that the dogmata of Robert Stephenson as to the impossibility of keeping it open were purely chimerical—has stated, that he would undertake to irrigate the whole land of Egypt, *i. e.*, all its tillable land, from that canal.

A condition produced by the relations of the salt water or great ship canal and the arid climate of Egypt, which Stephenson never thought of, has since been carefully taken into account, and it is now certain that whenever the sea shall be let into and fill the Bitter Lakes, the evaporation from the water surface alone will be such as to cause a considerable current through the canal, which, according to Stephenson, would be "no more than a stagnant ditch;" indeed, the question has been raised whether the scour due to this cause and to alternate action of the tides, though these are small at either end, may not prove more than desirable. The effect, however, of this evaporation will unquestionably be to totally and rapidly change the whole climate of Egypt, so that, irrespective of any irrigation, it will probably become sufficiently moist to gradually put an end to the Egyptian Sahara, through the unseen working of the forces of nature. Should this even in a minor degree be realized, and there can be little doubt upon the subject, it will be probably the most wonderful result in the modifying of cosmical forces as found in nature ever achieved by human means.

England has all along occupied a most unenviable and unfortunate position as regards this grand project, of which France may be so justly proud, and the completion of which we hope the Emperor may live to see, and to know that it will be one of the events by which history will mark his reign. But we will not go back upon the unpleasant track of misjudged policy, mainly due to Lord Palmerston's political prejudices as to Eastern affairs, sustained by R. Stephenson's engineering misjudgment, in which the facts and deductions were fitted for the political foregone conclusion, rather than to nature and reality. The recent tardy sort of half retraction of ancient opposition and prejudice on the part of the *Times*, and some other English leaders of opinion, is but a pitiful display of grudgingly admitted error and half-given praise. The old story, "it will never pay," however, is still raised, but no attempt is made upon any solid and sensible basis of figures, in Great Britain at least, to prove that that is so.

RAILWAY ACCIDENTS.

HASTY CONSTRUCTION—IMPERFECT EARTHWORKS.

The "Railway News" divides railway accidents into two classes; those arising from moral causes, such as disobedience of orders, and those arising from physical causes, such as mal-construction. Particular reference is made to the settling of embankments. A few inches above section line are generally allowed, but it is never enough; embankments have been known to shrink a foot to the yard—that is to say, an embankment of thirty feet high, left full height, has been known, after excessive rain, to sink ten feet and some even more than this—sand-banks not so much. Here, then, is the primary cause of numerous railway accidents. The construction of railways is always hurried forward; cuttings and embankments are often begun and finished before any wet has been on them; they are prettily carried out and completed according to the plans and sections, the sides are nicely soiled and sown, and the young engineer, having his exact depth of cutting, exact height of embankment, and exact two feet of ballast, all according to specification, is satisfied. In nine times out of ten the practical navvy knows this is wrong; but it matters not to him. He must obey the engineer, and he gets paid; and in the contingency mentioned he may possibly get paid a second time for the same work. Banks should be—and are supposed to be—constructed of half round form, the centre six inches higher at least than the sides, in order that, when the water makes its way through the ballast, it may meet this convex formation, and so be sent both sides out over the embankments—good in principle and effectually preserving banks in good order when thoroughly carried out; for it is not the quality of rain that falls that spoils banks and renders them dangerous, but the quantity that finds its way into their centers. But on the contrary, when the rain comes the banks go. The ballast is now on; they cannot be opened out and remade, because of the traffic and for other reasons; so more ballast is heaped on, as many feet of it in many instances as there should be inches, the consequence being that the symmetry of the bank is lost, the rotundity between ballast and formation is gone, the water settles into the embankment, and ballast for the future does more harm than good, the water finding its way out by means of slips and other channels that strain the permanent way. The sleepers may be sound, the rails good, and the fastenings of the most approved kind; but if this strain, unprovided for in office books, comes on, away goes the road, and under some extra speed or weight, or during the 48 hours between Saturday and Monday that the platelayer's watchful eye is off his beat, the fastenings are unfairly tried, the guage is forced out, and off goes the train.

This was, no doubt, the case at Tuxford, on the Great Northern, some five or six years ago. About two years ago it was the cause of that terrible accident on a heavy bank on the Chatham and Dover, and more recently, on the branch line between Leamington and Rugby, this was evidently the real cause of the accident. Of course accidents occur on banks and in cuttings too from other causes, and it is not denied that sharp curves and steep gradients do their part; but the above is chiefly the cause of the class of accidents we are now discussing, and they are only to be avoided by the non-ballasting of embankments until they have had two or three seasons on them, and have had time to become permanently consolidated. If lines must be opened before that occurs, less risk a thousand times to run (at reduced speed, if you like) over banks without any ballast at all. By good management and constant packing, the road can be maintained almost as well without, as with ballast; indeed, very much better than on banks where the super-quantity of ballast acts only as a perfect trap to catch and hold all the rain that falls; and then, after two or three winters have been on the banks, the road may be finally lifted, set, and ballasted, and it will never cause either trouble, uneasiness or accident.

PROGRESS OF ELECTRO-METALLURGY.

COATING SHIPS' BOTTOMS—SILVER PLATING, ETC.

From the "Mechanics' Magazine."

In the year that is just ended, but little has been added to our knowledge of the laws of the electro-deposition of metals, and not a great deal to the application of laws already known; still, some progress has been made, in the modes of carrying out these arts. Last year we noticed a new application of electro-coppering, as applied to the coating of ships for the prevention of fouling and corrosion, which had then but newly been tried, and we were then in hopes that by its means copper would soon be successfully applied to the bottoms of ships for their protection, but yet little progress has been made in that direction. Not that a firmly-adhering coating of copper cannot be applied to iron; we have seen this done repeatedly, but the difficulty is in applying it to ships. It can be done to ships' plates before being built into the ship; but the rivets must be coppered also—yet, if coppered, how are they to be riveted? Even if copper rivets were admissible on the score of cost and strength, they could not be on the score of electric action. For if they contained lead, as almost all commerical copper does, they would become electro-negative to the electro-plastic copper, and so assist to destroy the coating of the plates. It is true that electro-plastic copper could be made into rivets, but this would be at double the cost at least, and this would enhance the price enormously, the rivets required being both very large and numerous. But besides these considerations, copper rivets would not be strong enough. Are we, then, to give up all hope of coating iron ships with copper? By no means; but it will not be by the direct application of the copper to the iron. We think the difficulties of such a process are too great to be successfully overcome. The process which appears to us most likely to succeed, is to coat the plates of iron with copper by electrolysis (the iron giving strength), and with these plates to sheath the bottom of the ship, between the the sheathing and the ship an insulating substance being interposed. Of course, in this way, a ship could be sheathed with ordinary commercial copper, but the sheets would have to be of sufficient thickness to prevent buckling and bulging from the insulating material, so that with plates wholly of copper the sheathing would be six or eight times the cost of that we have hinted at. We should like to see thin iron plates coated with copper, applied as sheathing on a large scale. We have seen it tried on a small one, and have but little doubt of its success on the large.

In electro-coating with silver, as applied to copper, brass and German silver, there is nothing new; except with regard to the coating of the alloy of lead and tin (common soft solder) with silver. This practice has become much more extended, and is a deception and a cheat. The forks and spoons are roughly made of a common kind of German silver, or, rather, a highly speltered brass, without a particle of nickel in it, and then coated with common solder by immersion in the melted metal; they are then easily rubbed down smooth, and the expense of filing, burnishing and polishing saved, and this is the reason why this practice has been resorted to. There certainly is more difficulty to the ordinary practitioner in coating this alloy with silver than in coating German silver, brass or copper. The same method cannot be pursued with this alloy as with the above metals. Mercurial cyanide or nitrate is of no avail to prepare it for the silver; instead of this as a preparation, the spoons or forks are suspended in a boiling solution of caustic potash or soda for a short time, and then transferred quickly to the silver cyanide solution, to which is attached a strong battery, so that they may be quickly coated with silver, and the action of the cyanide solution on the alloy is prevented by rendering it strongly negative. When they are coated they look as well as other spoons and forks, but they soon chip, owing to the softness of the alloy under the silver, as well as the imperfect adhesion of the silver to the alloy.

There is another branch of electro-coating, wherein some progress has been made during the past year, that is the coating of iron, steel, and cast iron with copper and silver. To make silver to adhere firmly to iron and steel has been a desideratum much sought after for many years; indeed, ever since electro-plating was discovered. It has always been found much less difficult to make copper adhere to iron than to make silver adhere to it; consequently, it has hitherto been the practice to coat common dessert knives and nut-cracks with a thin coat of copper and then with a coating of silver. But these are much inferior to the solder-plated knives, called close plated, which is a thin sheet of silver soldered on to the blade with common solder. These are called the best plated knives, though plated with soft solder, because hard or silver solder is not applicable to plating knife blades, on account of the heat necessary, but to carriage, harness and coach fittings, hard solder plating is applicable, but its expense prevents it being much used. This new process referred to above is equal to hard solder plating, but cheaper than soft solder plating. The inventor of it calls it pyro-plating, because the fixing of the silver is done by heat, as also the preparation of the articles for silvering. Some four years ago, a patent taken by Mr. J. Baynes Thompson describes a process for obtaining a pure surface, whereon to deposit the silver, viz: by depositing a film of iron on the article. But within the last six months the same gentleman has taken out another patent and abandoned the previous one. In this new process there is no intermediate coating of any other metal, the silver being deposited direct on the iron or steel. The surface of the iron is purified by nascent hydrogen, the hydrogen being produced by the electrolysis of hydrate of potash or soda; the inventor prefers hydrate of soda. With care, no other salt need be added to this solution, but in manufacture such care can hardly be expected; therefore, it is expedient to add a small quantity of one of the compound cyanides: those preferred are the nickelo or cobalti-cyanides of potass. The necessity for these salts is this: If care be not taken to regulate the current of electricity according to the strength of the solution and the number of articles in it, as well as the heat of the solution, sodium will be deposited on the articles as well as hydrogen, and if transferred to the silver solution with that on, the silver will not adhere. The compound cyanide prevents that.

When the article is coated with silver it is subjected to a heat of between 400 deg. and 500 deg. Fah., so as to fix the silver, and after that it will stand a red heat without injuring the coating. Knife blades and all cutting instruments are silvered at a pale straw temper, so that the burning in or fixing of the silver may bring them down just to a proper cutting temper. We understand that the inventor has been fitting up a manufactory for the production of silvered articles in iron and steel, and that it will very soon be brought into full operation. Beyond these, nothing further of note has been done in electro-metallurgy; and though the advance during the last year has not been very striking, still gradual progress has been made.

SINKING MASONRY IN MARINE MUD.—Contracts will shortly be issued for the construction of a floating basin at Bordeaux. Preliminary surveys and trials have been made, the result of which is that the difficulties of construction turn out to be less formidable than was imagined; the works will have to be carried out on a bed of marine mud about twelve yards in depth, but which is easily traversed by blocks of masonry fourteen yards high and with a surface of about six yards. Three wells have been made by means of blocks formed at the level of the ground, and which descend by their own weight as fast as the soil is taken out from the well. This operation presents, it is said, no real difficulty when the mud is dense enough to prevent the water rising in the well, and if a stream should flow in, a pump capable of lifting about 300 gallons a minute would soon pump the well dry. Under the conditions above mentioned the masonry descends to the depth of thirteen yards, exclusive of a stratum of very pure sand, four feet or five feet thick, which lies beneath the mud. Masonry thus placed has the solidity of a rock.—*The Engineer.*

RESISTANCE AND TRANSMISSION OF MOTION.

By Prof. Henry Morton, Ph. D. From the Journal of the Franklin Institute.

There are a number of phenomena more or less directly connected with the effect of high velocity in overcoming resistances, which are commonly regarded as forming a class by themselves, and requiring a special hypothesis for their explanation, or if treated in the established method, calling for an exercise of faith in a train of reasoning not in itself quite unexceptionable, which is at the least a sort of discomfort to ordinary minds. As an illustration of the phenomena to which we allude, we may cite the oft-quoted experiment of shooting a tallow candle through a pine board, the piercing a slate with a pistol ball, without cracking it, &c.

In an able paper by John C. Trautwine, C. E., entitled "Remarks on Force, Motion, and Inertia," published in the "Journal of the Franklin Institute," Vol. XLIV., p. 197, some of these difficult questions are very fully expressed. We will quote, for want of space, but one of the illustrations used, although we would strongly recommend the article to all interested, as an accurate and entertaining discussion of a subject which has been inadequately treated by some even of the highest authorities. After various other and more elaborate illustrations, Mr. Trautwine says: "The ordinary coupling between a locomotive and a heavy train, would break, under the action of an engine capable of imparting to the train at one impulse, a velocity of forty miles an hour; yet it safely transmits the same amount of moving force when imparted by a succession of milder impulses," and further on, "it would seem, that *moving force will of itself* sever mediums through which we may attempt to *transmit* too much of it, to *unresisting matter*, as well as to resisting force."

We believe that the obscurity of this subject will be greatly relieved, if only a little thought is given to the nature of those molecular forces which are the most usual active agents in the resistance and the transmission of motion. It will then be seen that these are forces which differ in nothing but their range of action, and intensity, from gravity, or other like energies, and may be fairly compared with them in their mode of action.

There is however, another point, which, though self-evident, is apt to be overlooked in our study of all forces, and that is their relation to time, in the respect, that the effect of any force must be proportional to its time of action. Thus, if a force is capable of producing a certain effect in one instant, it will do the same twice over in two instants, and can do but half as much as this in half the time. We should then first regard the particles of bodies as maintained in their relative positions, not by any general and indefinite condition of contact, but by the constant action of certain forces of great but limited power, and exerting this power, not without reference to time, but on the contrary, with entire dependence upon it; so that each element is exerting so much force in so much time, more in more time, less in less time, in a direct proportion.

These general principles being premised, we will presently assume a case involving the transmission of motion, and test our theory in its explanation. Our conception of this subject will be rendered more easy, however, if we first consider a parallel case in which gravity might take the place of the transmitting or molecular force. Imagine the earth at rest in space, with a heavy body in contact with it at some point. If, now, the earth received a motion in a direction radial to the point of contact and away from it, the heavy body would remain in contact so long as this motion was not greater than that of a body falling from a state of rest, *i. e.* (sixteen feet in the first second, and so on). In other words, the attractive force between the heavy body and the earth (which here represents the molecular force of our actual experiment), is just equal to that which we express by so much matter (the weight of the heavy body), moved sixteen feet from a state of rest; this power being put forth in the time of one second. If, now, we required a greater force to be transmitted by this attraction of gravity; either by asking it to move a greater mass at the same rate (as by connecting the heavy body by a string, with another so placed as to be free from all resistances to motion), or by demanding a higher velocity (as by supposing the earth to move more than sixteen feet in the first second), we should simply rupture the connection between the earth and heavy body. By keeping within the limits of the *transmitting* force (which in the above case was gravity, but might be any other), we can transfer, part by part, any amount of force to the second body, which will be converted into motion in it, and be so stored up and accumulated without loss, all resistances being removed.

We will now take up an actual case of transmission to which our principle should supply an explanation. A weight, W, rests without friction on a level plane, and a power, P (derived say from the action of gravity upon a heavy body), is caused to act upon it by means of a cord passing over a fixed pulley. In an instant of time, gravity exerts a certain pull upon the heavy body, which we may assume to be transmitted instantly to the first point of the cord; but how is it to travel along the cord? It is clear that the only mechanical connection between the successive points of the cord, is their *cohesive attraction for each other;* it is then by what we may be allowed to call a *stretching* of this attractive force, that the power, P, can be transferred along the cord to W, and by no other means. Now, this molecular force is, as we have already seen, properly expressed by, and in fact constituted of, so much power in so much time. If, then, we draw one of these atoms from another with a force which is greater in the *same time* than that uniting them, a rupture will occur, and so much force only be transmitted as was exerted by the molecular power during the time that the weight was acting upon it.

The questions and conditions here noticed, lead us to another cognate subject of similar difficulty, and amenable to similar treatment; we allude to the relations between the moving force and the work done by a moving body. We say and know that the *vis viva* or work done by a moving body, varies with the square of its velocity, while we know, by our previous reasoning, that the force expended in giving it that velocity, only varies with the velocity itself. Thus the force of gravity will give a falling body a double velocity in a double time, during which it must have exerted a double force upon it. Here, then, we have a double force, doing a quadruple work. Is this because, by some wonderful and recondite property inherent in "velocity," the double power has been indued with an again doubled efficiency? Many writers leave us to think so; but we, on the contrary, believe that the work done *only seems to increase* more rapidly than the power implied in the increased velocity, by reason of a *loss of efficiency* in the resistances, in the overcoming of which the "work" consists, and in fact, that work in this sense, is no true measure of force.

As we have before seen, the molecular forces (which are those that most commonly play the part of resistances) as well as all others, exert powers proportional to the times of their action. If, then, a moving body with a certain velocity, overcomes a certain number of these resistances, or, for example, penetrates a medium to a certain depth, before its motion is arrested, it has overcome so many resistances, each acting for such a length of time. If, now, the same body with a double velocity, meets the same medium, it will penetrate each resisting element in half the time, and so receive from it but half the resistance it experienced before. If, then, its total force were *only equal* to what it was at first, it would go twice as far, or overcome twice as many resistances; because each of them would be but half as effective as at first. But as we know the double velocity implies a double total force, and thus, considering the doubling of the force and the halving of the resistances, we see why the number of these overcome, or the work done, should be fourfold. Similar reasoning would apply to the case of a body resisted in its upward motion by the force of gravity. A double velocity would give a four-fold height to its upward path, because, traversing each distance in half the time, gravity would exert but half its former effect within the same space, and so on, as before followed out. The body would come to rest when exposed *for a double time* to the resisting force of gravity.

It may be objected that the time of action is not the true measure of a force, but rather the distance which it causes a body to move in a given time. But that this is not so, will be seen when we consider that any velocity once implanted in a body, needs no force to maintain it, so that all the motion afterwards executed by reason of that element, is a clear gain having no equivalent of expended force as its representative. Thus, a falling body acquires during the first second, a final velocity of thirty-two feet per second. If gravity then ceased to exist, it would still travel this distance in the next second, while if the force still exist, and is to be expressed by the motion produced, we would have it responsible in the first second for sixteen feet, and in the next for forty-eight. It is precisely this which introduces the philosophical error into the method of estimating force by the product of mass, into the square of the velocity.

But again, it may be said, the true measure of a force is the heat it develops, and this, as we know, varies with the square of the velocity. We would reply that all development of heat is unquestionably of the nature of overcome resistances. Thus the vibratory motions given to the atoms of bodies, are given in opposition to and by overcoming their molecular forces, and therefore, as in other cases, these forces will each individually oppose a *shorter* resistance to a body with high velocity, and thus render a greater number of their companions necessary to counteract its motion. In other words, the previous explanation may be applied word for word to this case. Or, we may say, the change produced in the individual atoms of a resisting medium, which we have heretofore called overcoming of their resistances, *is* heat. Therefore, if a double velocity overcomes a four-fold number of resistances, it develops a four-fold amount of heat.

In conclusion, we would again remark that the foregoing discussion is in nowise intended as suggesting a new system of mechanics. The rules at present employed are perfectly correct in their working, and more convenient in form, we think, than any which could be established on another basis. Like many rules and methods in mathematics, they are without reference to the rationale of the process, but accurately fitted to its requirements. Thus, for example, to take a simple case in arithmetic, in place of dividing one fraction by another, we invert the second and multiply. This is perfectly correct and unobjectionable as a method of obtaining certain results, but if the final expression (e. g. $\frac{1}{2} \times \frac{3}{1}$) were regarded as a rational explanation of some process (the inverting step being ignored), it could not well convey a very true or satisfactory impression. So when we calculate the efficiency of various forces by the formula $f = mv^2$, we are simply transferring one v from the denominator of a fraction expressing the resistance, to the numerator of the quantity expressing the force, which we have a perfect right to do, provided that we recognize this as a *mathematical process*, and not as the expression of a *physical fact*. Our object in writing the above, is to make clear that this *is* the actual state of the case, and thus, in this and the other points noticed, to offer to those who may feel the appetite for such a supply, the reasoning which has satisfied in ourselves the craving after a rational account of things that had a certain air of paradox about them, as commonly enunciated.

THE DRYING PROPERTIES OF VARIOUS PAINTS.

From a Paper by Charles Tomlinson, F. R. S., read at the Society of Arts, Dec. 9th.

The question we have to consider is "Why does paint dry?"

VOLATILE LIQUIDS.—When we boil water a process of evaporation goes on, and the evaporation is not superficial merely, but from every part of the liquid. Again, if we apply heat to oil of turpentine contained in a retort, it will boil a little over 300 deg. Fahr., and the vapor may be collected and condensed in a cooled receiver; but if we try to boil linseed oil, for example, it will not only not distil over, but it will blacken and decompose instead of boil. If we moderate the heat so as not to carbonize it, then it will lose about one-sixth of its weight and become thick, tenacious, and viscid; forming what is called printer's varnish. Raise the temperature above 600 deg., and if air be present the oil will take fire and burn quietly without further external heating, until nothing but tar or charcoal is left. If, however, the burning be interrupted by closing the vessel, a brown viscid substance will be left, known as birdlime.

Turpentine belongs to a class of oils known as *volatile;* that is, they can be raised into vapour by means of heat, and under certain conditions will evaporate or dry up. Linseed oil, on the other hand, which cannot be distilled, belongs to a class of oils called *fixed.*

FIXED OILS, PAINTS.—House paint, omitting the coloring matters or stainers, consists of three ingredients: 1st, white lead or white zinc; 2d, a fixed oil, such as linseed or nut, used for the purpose of reducing the white to a soft paste, to which is afterwards added variable proportions of linseed or other oil for thinning the paint; 3d, the dryer. Dryers consist of litharge, oxide of manganese, and sugar of lead. Linseed oil is heated with about one-twentieth of its weight of litharge, which the oil completely dissolves, and is then used as a dryer. A similar heating with manganese or sugar of lead also improves the so-called drying properties of the oil.

OXIDIZING OIL—EXPERIMENT.—But what would be the effect of omitting the dryers altogether in the composition of the paint? I have no doubt most painters would say that the paint would never dry. Let us see the result of a careful experiment performed by Chevreul some years ago. Four oak strips were painted, each on one side, with a paint composed of white lead and linseed oil, and the other side with a paint composed of white zinc and linseed oil. The dryer was omitted in all cases. The strip No. one was exposed to the air to dry; No. two was put into a bottle of the capacity of 3.52 pints and closed; No. three was put into a similar bottle, containing dry oxygen gas; No. four was put into a similar bottle, containing dry carbonic acid gas. After 24 hours, No. one lead paint was almost dry; the zinc paint had set, but was not dry. No. two lead paint was almost dry; the zinc paint had set, but was not dry. No. three lead and zinc paints were perfectly dry. No. four paints were still wet and fresh, and had undergone no change. After seventy-four hours, Nos. one and two paints were perfectly dry. No. four lead paint had almost set, but it had no adhesion to the wood, and could be easily removed by friction; the zinc paint had undergone no change, but stuck to the finger like fresh paint. In another experiment it was shown that in drying in a confined volume of atmospheric air, the paint had absorbed all the oxygen, and left nothing but pure nitrogen in the bottle.

Paint dries, not because it loses anything, as in the case of ordinary drying by evaporation, but because it absorbs oxygen from the air, and solidifies in combining with it. The drying of paint, is not, therefore, a mechanical effect, as in the case of evaporation, but a chemical one, in which there is a change of properties attending a change of state from liquid or viscid to solid. Linseed oil exposed to the air in thin layers dries up into the form of a resinous, transparent, moderately elastic mass resembling caoutchouc. This property of absorbing oxygen and gradually becoming solid, also applies to walnut, hemp, poppy, grapeseed, safflower, and some other oils, and hence such oils are termed drying oils. In undergoing this change these oils undergo slow combustion, and give off carbonic acid. Under certain conditions the drying oils absorb oxygen so quickly as to take fire, as when the cotton-wool, tow, &c., used in cleaning machinery is thrown aside, and has thus led to conflagrations.

According to Mulder, the difference between non-drying and drying oils arises from the presence of oleic acid in the latter. He compares drying oils to blood; they absorb oxygen and give off carbonic anhydride. To prove this in the case of linseed oil, fragments of pumice stone were ignited, left to cool, and then put into a bottle, and the pumice was moistened with boiled linseed oil, the effect of boiling being to raise the oil into a state of greater activity. Air previously deprived of carbonic anhydride, was next passed over the pumice, and then into a vessel containing baryta water, which, in a few minutes became turbid from the presence of carbonic acid, due to the slow combustion of the oil. Roughly speaking, the setting of paint is due to the absorption of oxygen; hence we can understand why the painters, in order to prevent their brushes from getting hard, put them into water when they leave off work; and also cover a painted surface with water when they want to keep the paint from setting.

NON-DRYING OILS AND PAINTS.—The oils that do not absorb oxygen, are rape, colza, olive, almond, and many animal oils. By exposure to air they become gradually changed, but in a different manner as compared with drying oils. They become rancid from the fermentation of the cellular substance of the plant or animal from which the oil was obtained. They lose their color, and, to a certain extent their fluidity, and acquire an acrid, disagreeable taste. Such oils are, of course, quite unfit for the purposes of the painter, although there is ground for suspicion that linseed oil is sometimes adulterated with a cheap fish oil, the result of which in the paint is to produce a disagreeable kind of stickiness which is all but permanent.

Besides white lead, or white zinc, as the basis of paint, white antimony has also been proposed. In order to determine the relative merits of the three, M. Chevreul instituted an experiment in which ten grammes (154 grains) of pure linseed oil were mixed up with sufficient quantities of the three solids without the addition of any dryer. It was found that the zinc paint covered a less surface than the lead, but more than the antimony paint. The drying of the different coats of the three paints required very different times, as will be seen in the following table:—

Coats.	Lead Paint. Days.	Zinc Paint. Days.	Antimony Paint. Days.
First	4	18	50
Second	$3\frac{1}{2}$	15	28
Third	3	5	27
Total	$10\frac{1}{2}$	38	105

Hence it appears that lead paint dries much more quickly than zinc or antimony paint. Indeed, unless it were possible to hasten the drying of zinc paint by the addition of a dryer, it would be of very little use in industry, since the practice of house painting requires that not more than two or three days shall elapse betwen the application of the first coat and that of the second.

Antimony paint is also too slow in drying to be used. A tin paint was also tried, but the oxide of tin was found to delay the drying of the oil. Pure linseed oil dries more quickly on glass than when mixed with oxide of antimony, so that this oxide is actually anti-siccitive relatively to glass.

Dryers.—We now come to the dryers, such as litharge, manganese, etc., and their action is very remarkable in causing the paint to absorb oxygen quickly and decidedly For example—two cubic centimetres of linseed oil absorbed, in thirty days, 2.445c.c. of oxygen; but the same quantity of manganese dryer absorbed 21.45c.c. of oxygen; while a mixture of the two, consisting of 1.56c.c. of linseed and 0.44 of the dryer, absorbed 30.826c.c. of oxygen. That is, the absorptive, or, as a painter would say, the *drying* power of the mixture is far greater than the sum of the powers of the two oils, since 1.56c.c. of linseed oil absorbs of itself 1.985c.c. of oxygen, and 0.44 of the manganese dryer 4.749c.c. of oxygen in thirty days, the sum of the two absorptions being 6.714c.c. But the mixture really absorbed 30.826c.c., or more than four and a half times as much as the same fluids absorbed when exposed separately.

Experiments, scientifically conducted, have also shown, that, in preparing his dryers, the painter wastes both good materials, fuel and time. He boils his oil too long, and maintains the temperature too high. The usual mode of preparing dryers is to heat the linseed oil in an iron pot until it appears to boil. The surface is skimmed from time to time, and after from three to six hours, about one-tenth, by weight, of litharge is added, and the heat is maintained five or six hours longer; or 100 parts of very old linseed oil is heated about six hours, when six parts of litharge and about three of burnt umber are added. The heat is continued six hours longer, when the liquid, after being left quietly to cool, is decanted. For the manganese dryer, the oil is heated at the so-called boiling point during five hours; peroxide of manganese is thrown in, and the boiling continued for eight hours. We have already seen that the boiling is not the formation of vapor, but the escape of gas-bubbles due to decomposition.

Chevreul's experiments prove that pure linseed oil is more siccative after three hours' boiling than if not boiled at all; but is less siccative after five hours' boiling than after three. The oil boiled during three hours with one-tenth of litharge is much more siccative than if heated without the addition of this oxide; so that the drying property is not conferred on the oil by the action of heat, as some have supposed, but it is by the mutual action of the oxide and of the oil, assisted by a high temperature, that the drying properties are developed. Litharge is more siccative than manganese; and what is very curious is, that litharge, heated once with oil, is more active than fresh litharge. It is still more curious, that manganese that has been heated several times with the oil is more active than fresh manganese. But this excess of activity in the oxides is no longer exerted on oil that has already been boiled five hours. All the experiments proved that the drying property of linseed was injured by a prolonged heating at high temperatures; and the remarkable and unexpected result came out, that linseed, exposed to the temperature of from 100° to 176° Fah. during six hours in contact with ten per cent of manganese, can be used immediately in painting without the addition of any other dryer. Linseed oil alone, exposed to a similar moderate temperature, improves in its siccative property, but not sufficiently so to dispense with the manganese. A very energetic dryer is obtained by boiling the oil for three hours only in contact with fifteen per cent of the metallic oxide.

This completes the first branch of Mr. Tomlinson's paper. In the following number we propose to continue the subject of paints, especially the drying of paints on metals, various woods and other substances, and the influence of turpentine and other ingredients.

RECENT RAILWAY WORKS AND PROJECTS.

Compiled from "Engineering," "The Practical Mechanic's Journal" and "The Engineer."

The great railway work of the year has undoubtedly been that across the plains and mountains of Western America—the Pacific Railway. The particulars of this work have been so often given that we need only say here that will form an unbroken line of railway communication across the continent from New York to the waters of the Pacific—a distance of over 3,000 miles, of which a few hundred miles only, await completion. It possesses, however, but little engineering interest beyond the fact that it crosses the two highest summits yet attained by railways, the summit in the Rocky Mountains being 8,242 feet, and that in the Sierra Nevadas 7,042 feet above the level of the sea, the mountains themselves rising considerably higher. These great elevations are, however, approached from such long distances, except on the Pacific slope, that there is nothing exceptional in the gradients or curves, nor are there any heavy tunnels or earthworks, nor important bridges. Indeed the "track laying" has gone on at the rate of three miles or more daily in each direction, and the line is expected to be open throughout in July next.

The most interesting line opened during the year is the temporary railway over Mont Cenis, overcoming a summit level 6,870 feet above the sea. On the Italian side the gradient for some considerable distance is one in twelve, while for a good deal of the distance on both the French and Italian slopes the inclination is at nearly the same rate. Upon all the inclines steeper than 1 in 40, in the whole line of 48 miles, a middle rail is laid in the very narrow gauge of 3 ft. 7½ in., and additional adhesion is obtained by means of horizontal gripping wheels, worked by the engine, and pressed with a force of from 5 to 15 tons against this mid rail. There are curves of two chains radius connecting the zigzags by which the line ascends the mountain. Of the working of the line and its prospects we have spoken elsewhere.

The Mont Cenis tunnel, and its progress we have recently described. The promised success of this undertaking has led M. Flachat, president of the society of Civil Engineers of France, to propose other lines across the Alps. After pointing out the daring rapidity with which all the rest of Europe has been furrowed by lines of railway, and showing that the territory of the Swiss Confederation is far behind the rest of the Continent in this respect as in others, he states that three great railway lines ought to be opened across the Alps, viz: by the Lukmanier, the St. Gothard, and the Simplon passes. While France is most interested in that of the Simplon, Germany is most so in Lukmanier. Switzerland is hostile to any line over the Simplon, because of its jealousy of France. Italy hails with pleasure any or all of them, having no choice except for whatever line shall enrich her most. M. Flachat after reviewing the success of the Mont Cenis tunneling, which is now about 1.9 meteres per day for each face of heading, and the probable improvements in tunneling machinery, concludes that tunneling in the Alps, upon a scale such as these and like vast ranges of mountains demand, is a matter of certainty now as to success, economy, and amount of cost, and that hence huge tunnels ought no longer to oppose the progress of the engineer in opening out such mountain barriers.

The particulars of the various tunnels proposed, compared with the Mont Cenis, are as follows:

Name of Tunnel.	Length. Metres.	Summit above sea. Metres.	Cost. Francs.
Mont Cenis.....	12,220	1,200	61,100,000
Simplon.	12,080	1,300	60,000,000
St. Gothard....	15,480	1,110	78,000,000
Lukmanier.....	1,710	1,750	30,000,000

Without going through his figures, which are probably far from conjectural—for it is to remembered that the St. Gothard line, at least, was surveyed and laid out in detail some years ago—he arrives at the conclusion that the total cost of establishing the three great linos of passage, and placing them in full communication with the railway systems of the countries to the north and south of the Alps, would reach a total cost of 387,800,000 francs, or some $78,000,000.

Largo railway undertakings are going forward in Russia, Hungary and Roumania; but in India and tho colonies railways have made but slow progress. No active steps have been taking towards the construction of the Intercolonial Railway through New Brunswick, although the large loan for making it was guaranteed by Parliament a good number of months ago, and half the loan has been taken up.

A railway has been at last begun across the Isthmus of Honduras, between the Atlantic and Pacific oceans. The length is to be 231 miles, overcoming a summit of 2,956 feet. The cost is set down at £8,000 per mile, but enough is known of the almost impenetrable forest and the unhealthy climate of Honduras to convince us that a far larger sum than this will be necessary.

An agitation, without any substantial results, was commenced, some months ago in Canada in favor of 3 feet 6 in. gauge railways. The whole scheme appears to have dropped through, and singularly, no particulars of the working and financial results of the same gauge on the Queensland railways have been furnished by the parties who have promoted other lines of the same gauge. A railway across Canada is proposed, which, if carried out, will absorb a capital of some $20,0000,000.

In Turkey there is a fine field for the construction of railways, and one scarcely inferior in China. *

As to French railways, there is an impression that it is because Government so limits them in extent that they all pay well, and that they are too few to accomodate the people. The list under survey or construction at the beginning of the year would seem to show that this want, if it exists, is being rapidly supplied. Among the principal new lines, are the following: Paris to Dieppe direct; Orleans to the sea by Honfleur, Lisseux, &c., 165 miles; Soissons by Buire, Vervens, Lugny, &c., to the Belgian frontier; Auch to Toulouse; Cercy-la-Tour to Grilly-sur-Loire; Cambray to Gannes; Niort to Cholet, 80 miles; Bergerac to Libourne; Méru to Beauvais; Flers to Condesur-Norreau; Avallon to Dracy-Saint-Loup; Aix to Marseilles; Epernay to Romilly; Napoleon-Vendeé to La Rochelle; Yevot to Dieppe; Havre to Lille; Bordeaux to Pauillac, and various branches of the Orleans and Rouen, and the Northern railways, and a line connecting the Eastern Railway of France with that of theDuchy of Baden, between Saint Louis and Leopold's Lake.

In Great Britain although the past year has not been marked by active railway enterprise, several important undertakings have been completed or carried forward. In and near London the principal works have been the Midland Extension, now open through to Bedford and the north; the Metropolitan and St. John's-wood, opened to the Swiss Cottage; the Metropolitan Extension, now completed to Westminster, and the new line of the South-Eastern, *via* Chiselhurst and Sevenoaks. The Midland Extension, with its four lines of rails and its great station at St. Pancras, is now one of the most important of all the railways out of London, and it may be expected not only to cheapen the transport of coal from Derbyshire, but almost literally to build up a new series of suburban towns extending even beyond St. Alban's. The St. Pancras station has been so often described, that it need only be noted that its magnificent iron roof has a clear span of 240 feet, the widest yet attempted, and that it forms altogether the finest example of railway architecture in the kingdom. The Metropolitan and St. John's-wood presents no striking features as an underground line, the ascent of one in 27 to Hampstead not having been begun. When completed, the line is to be 2¾ miles long and is to rise 235 feet above the level at Baker-street, three-fourths of a mile being inclined one in 27, with a station half way up. The Metropolitan Extension, has some very interesting work. The Metropolitan District Railway, under the Thames Embankment, has made but little progress as yet; nor is the East London, to be carried through the Thames Tunnel, far advanced. The new line of the South-Eastern, *via* Sevenoaks, is noteworthy for a considerable amount of tunneling, and for heavy earthworks, and also for some especially fine brickwork in its bridges. The London and Brighton Company have opened a new line between Brighton and Tunbridge, saving fifteen miles in distance. The London and North-Western Company's new line, *via* Runcorn, to Liverpool, was to have been opened at the end of the year, this line, as our readers are aware, crossing the Mersey on a long bridge, of which the principal portion consists of three pairs of lattice girders, each of 300 feet span. The Caledonian Company have made a new line over which trains are run between Edinburgh and Glasgow, without the *detour via* Motherwell, the distance being the same as by the old Edinburgh and Glasgow.

The increase of railways in the United States, and the principal railway engineering

* See article in another column on railways for China.

works—bridges, tunnels, viaducts etc—recently completed and in progress here and abroad were referred to in the February number of this Magazine. It is not improbable, that we are on the eve of an important reform in railway engineering especially in England, and that we shall have cheaper and competing lines, serving the public at half the present cost. As to the Goverment taking over the existing costly and extravagantly worked lines, it is at least as likely that Parliament, and more likely that Congress, will leave the whole question of railway reform to private enterprise.

The Street Railway in England.—We long since predicted, says the "Railway Record," that its adoption in the suburbs, if not in the leading streets of our own metropolis, was only a question of time, and the act passed in the last session of Parliament authorizing the laying down of street tramways in the important and populous commercial city of Liverpool gave a *coup de grace* to an opposition which had contrived to interfere with the carrying out of a vast public convenience, which has been found to answer its purpose remarkably well in Salford, and in Staffordshire, and Birkenhead. The principal of the new companies seeking Parliamentary sanction is the Tram-way Company which proposes to form eight distinct lines in, and about London. Mr. Page the architect of Westminster Bridge has prepared the designs, and the traction will be conducted either by horse or by steam locomotives. There can be no doubt that every one of these will be opposed by the existing railway interests; and whether Parliamentary sanction will be obtained, will depend upon the temper of the new House.

On the other side of the question, Mr. Hulse, President of the Manchester Institution of Engineers says in his address on cheap railways, that unless the principal streets can be widened very considerably beyond what they are, unless people become accustomed to slow traveling, and unless the danger to which horses and other vehicles are subjected in crossing the rails is removed, I fear there will not be much likelihood of street railways becoming general. In some localities, and for some special descriptions of traffic, they may be found to answer tolerably well.

Temple Bar, so long and nobly preserved by the Londoners, is at last to give way to the exigencies of street traffic.

THE CONSTRUCTION OF RESERVOIRS.

The failure of the Dale Dyke or Bradfield reservoir at Sheffield, England, in March, 1864, causing the loss of some 300 lives and immense damage to property, has led the authorities of many cities here and abroad, to look very critically into the construction and durability of similar works at their own doors. In view of the breaking of several pipes in the embankment of the Druid Lake at Baltimore, the water board of that city have called upon Messrs. J. R. Trimble, C. P. Manning and J. H. Tegmeyer, engineers, to make an examination of that work, and from their late full and able report, we extract the following interesting and timely facts and considerations.

Construction of Ancient Reservoirs in India.*—Embankments in this country have been made without puddle trenches or puddle walls, the entire material of the banks being capable of resisting water. The earth was scraped up with rude instruments or by hand, carried in small quantities by men, women and children, trodden down by the feet of workers and animals, washed by monsoon rains, and dried and baked in the sun, until after many years of slow work, a close, homogeneous, enduring mound has been formed—instead of being thrown together in bulk from carts and cars, and inadequately tempered and compressed, as by the modern system. These works are remarkable for their vast extent. One has a bank 12 miles long and a reservoir circumference of 40 miles, the conduit pipe being 60 miles long. The reservoir of Abharya-Weva, is said to have been constructed 505 years B. C. It is now partially in ruins. The lake of Minery is 20 miles in circumference; the embankment is a mile long, covered with lofty trees. It is 2,000 years old and is still in use. The Cummum Tank is one of the earliest works, to which Hindoo history refers. Its length is five miles; its breadth three miles; its area eight square miles. The top of the bank or "bund" is 102 feet above the base with an average width at top of 26 feet; inside slope 3 to 1; outside slope 1 to 1½ to 1. It has two culverts passing through it, and a waste weir of 230 feet width to carry off surplus water, but placed half a mile from the embankment.

* Mr. Rawlinson's report on the failure of the Dale Dyke Reservoir.

The Dale Dyke Embankment.—This work for enclosing the waters of the Bradfield Reservoir, was situated in the ravine of the Dale Dyke or Loxley river, 6½ miles above Sheffield, and at a point 450 feet above that town. It was erected as a storage reservoir for supplying water power to mills and factories. The water-shed or gathering area discharging water in reservoir, is 4,300 acres. When full the lake had a surface area of 78 acres. Greatest depth of embankment 95 feet; capacity 114,000 cubic feet (855,000,000 gallons); top of embankment across valley 1,254 feet long; width of base 500 feet; width at top including four feet of puddle wall, 12 feet; inner and outer slopes of banks 2½ feet horizontal to one foot vertical; puddle wall or core inside of bank sixteen feet at a bottom and four feet at top, and 95 feet high; greatest depth of puddle trench or foundation of puddle wall below natural surface 60 feet The upper 40 feet of the embankment on both sides of the puddle wall, was composed of "rubble" materials by no means water-tight. The construction of the embankment was by railway wagons and carts, with tips, in layers three to five feet high, not saturated with water during the process, nor otherwise solidified. The materials were not of a good character for the construction of a water-tight embankment; and the mode of depositing and working it was objectionable. Two lines of cast iron discharge pipes eighteen inches diameter and 1¼ inches thickness, were laid under the embankment at a point 85 feet below its top. These were the only pipes in the reservoir.

The puddle trench descended various depths to the natural rock, or below it to impervious strata. Sinking the puddle trench was a tedious and costly affair. The springs in the strata through which it was sunk were so copious as to keep two steam pumps at work for two years, day and night. The waters of the river and of floods during this time, were diverted by a catch-water reservoir, and artificial channel on the side of the valley, to intercept and turn them from the excavation. This catch-water was afterwards broken by a freshet, which filled the reservoir to a depth of 50 feet in two days. An extreme flood on the area of 4,300 acres, draining into the reservoir would give a volume of 800 cubic feet per second; two pipes of eighteen inches diameter, 500 feet long, under a head of 90 feet, would discharge 84 feet per second from it. In extreme floods 30,000 cubic feet of water per minute, would flow into the reservoir; while both drain pipes and the waste-weir working free, would discharge but 19,000 cubic feet per minute; leaving a surplus of accumulated water of 11,000 cubic feet per minute, to threaten disaster. When the breach occurred at half past eleven, on the night of 11th March, 1864, the reservoir was full and a storm prevailing. The contents were discharged through the breach in half an hour, without any previous warning; passing down the valley at the speed of 18 miles per hour and sweeping all before them.

Cause of the Failure.—The two discharges pipes were laid in a cross trench, passing under the embankment and obliquely through the main puddle wall, at a depth of about 85 feet below its top, and at a point where the puddle trench was 30 feet deep below them. They rested in a puddle trench some 30 feet deep at the lowest point under the middle of bank, and were laid in puddle only. They were laid in a manner to almost insure destruction.

The puddle wall was too thin for a work of that magnitude. The material placed on each side of the puddle wall was of too porous a character, and much of it was tipped from railroad wagons, (directly into the embankment and not afterwards distributed), which is the most objectionable manner of constructing a water-tight embankment.

The objectionable mode of laying the outlet pipes, most probably fractured the puddle wall at the point of crossing; the loose state of the materials at the top of the bank let in the water; as the water rose in the reservoir, it most probably found it way down inside the puddle wall to the fracture above the outlet pipes, and hence the destruction.

Conclusions of the English Engineers.—Cast iron pipes should never be laid under such conditions as these. A culvert of masonry with an inner valve well, should have been provided. This culvert should have been on *solid ground in the side of the valley*, free from the loose earth of the embankment. Mr. Jackson, civil engineer, called in as an expert, said that he knew of a number of cases where pipes have been fractured, but of no grand disaster like this, of fractured pipes. He has laid pipes for twenty years, but would never again lay pipes *under an embankment in any way*, although *engineers have done so from Telford's time* down to this day.

The manner is which the bank was made is condemned. The layers should not have been over two feet thick, and should have been spread and consolidated with carts. The best clay puddle should not be trusted at less than one foot of thickness for each three feet of height of water. So that for an embankment 96 feet high, the puddle wall at the base should be 32 feet thick. At Bradfield embankment the puddle at the ground line was but sixteen feet in thickness, or one-half the strength required for safety. No puddle wall should be placed between masses of porous earth, but should be backed up on both sides with at least its own thickness of well selected materials, so as to prevent direct pressure from water on the inside, or any consequent cracking on the outside. The sinking of loose materials of earth on each side of a puddle wall may do mischief, unless such settlement takes place equally, evenly and slowly. A puddle wall should be wetted, worked and tempered into proper consistency. If the material on each side is not of the same sort and consistency, and does not set or build with the puddle, the bank is liable to injury.

If a deep trench continues to produce water, such water will soften the puddle and cause fracture of the puddle wall. Springs in the side of a puddle trench will inevitaaly waste and wash such puddle, unless special means are provided to divert the water. Undisturbed strata may bear and resist water safely—when, if broken and disturbed by deep sinking and heavy continued pumping for the formation of a puddle trench, the whole strata may be so ruptured, washed and disturbed as never again to become sound. A perfectly homogeneous bank on a stable substratum is alone safe. A puddle wall may be "a delusion and a snare."

Conclusions of the American Engineers, on Puddling.—It is a matter of much surprise to any one not trained and educated in the English school of Hydraulic Engineers, to find so little improvement has been made in that country for the last hundred years in the mode of preparing and applying puddle material. The English adhere tenaciously, and often blindly, to old customs and to the practice of early and eminent engineers. The evidence taken before the coroner's jury shows that errors in plan and construction have been followed from Telford down to the present day—errors now admitted to be plain, though heretofore undiscovered.

The early English engineers used "cut puddling," called so from layers of clay cut out of carefully selected material by the spade and packed carefully in the puddle wall as carried up with wetting, but not thorough saturation, to bind the material into one mass. The method of puddling by throwing materials into water, or by flooding the material already placed, called "flood puddling," originated in the United States, and was probably used first on the Baltimore Water Works, or, if used in England it was unknown to American engineers. Its advantages have been so manifest in practice that in our opinion it is immeasurably superior to all other methods, and should be adopted to the exclusion of old processes. When we reflect that water exerts an agency everywhere in causing loose earth to take a compact form in our fields, roads and common embankments, it needs no labored argument to prove that there is no process which can so soon and so effectually bring a reservoir embankment to the required condition of homogenous compactness. It must all be alike in consistency, without any part subjected to the risk of being left dry and porous, to subside unevenly.

The Druid Lake Works.—The Druid Hill Reservoir is made in a dry ravine, with an area of less than 100 acres to gather floods. It will have a bank of 60 feet width on top, with an exterior slope of 2 to 1, and an interior slope of 4 to 1, giving a thickness at base of 650 feet. The embankment has a puddle wall of 95 feet extreme height above natural surface, or 119 feet above the lowest foundation of puddle trench; a thickness at top of 17 feet and 36 feet at bottom. The firm deposits of ages from the hills of Druid Park collected in the ravine, are mixtures of clay and gravel, constituting an impervious stratum, which was properly left undisturbed in the construction of the reservoir, except to remove vegetable matter, &c., to about one foot in depth. The puddle trench was but 12 feet in depth to impervious strata of rock in the bottom of the ravine, without any springs and but a slight filtration of water, in fact, dry. The formation of the embankment was from clay, earth and decomposed gneiss and disintegrated granite, the gneiss supplying a pure clay from decomposed feldspar, and gravel from the quartz and mica happily blended, so as to ensure impermeability by its adhesiveness, and solidity by its compactness and specific gravity.

As to the fracture of the pipes in these works, and proposed changes, the report states: The first pipe fractured badly was the drain pipe, discovered twelve months after it was laid. In the fall of the same year (1866), the three influent pipes were found so badly injured as to render necessary their abandonment from prudential motives. The nature of the fractures were cracks at the bell-ends and from end to end and across the pipe, in some instances. These ruptures were first discovered by finding at a point just outside the embankment a small leakage of water discolored with iron. The roundness of the pipes was in some cases destroyed. Although these pipes were carefully laid in the manner frequently adopted elsewhere, yet four out of the seven have failed.

The engineers now consider the mode of laying these pipes objectionable, and their location under the bank injudicious. Pipes laid anywhere should rest on a foundation of perfectly uniform resistance, to preclude the possibility of unequal settling, which must fracture cast-iron. A perfectly solid basis would seem to be safest. The error committed was in laying part of the length in trenches and a part on piers. With so great a height of embankment above them, subsiding all the time, it could not be expected that either the pressure of the bank or the resistance of the foundations would be uniform. A slight difference in either would fracture the pipes. Those pipes remaining sound so far, must have had a uniform pressure upon them, or have presented a uniform resistance, so that no one part yielded more than another. But as we now see from experience in England, it would have been better to insert all the pipes in the reservoir through *solid ground above the embankment and remote from the puddle wall.*

This change, suggested by Mr. Wendell Bollman, "will have to be made." The cluster of four pipes is to be carried, through solid ground at a level of 60 feet below the contemplated high water lines of the reservoir, built on carefully prepared foundations, and enclosed in stone and cement, with several projecting collars of masonry to check leakage and obstruct any flow of water.* Each pipe is to be enclosed in a brick culvert, fitting tightly its outer surface, so that when in time the iron is destroyed from any cause, the enclosing arch shall form a permanent conduit in place of the pipe.

* See on this subject, Hon. Wm. J. McAlpine's paper, Van Nostrand's Magazine, Vol. 1, No. 1, page 10.

ORDNANCE EXPERIMENTS—NEW ENGLISH BOARD.—In view of the complaints of inventors, the defenses of Ordnance Boards and officers, and the present excitement on these questions among persons interested in ordnance improvement, no less in America than in England, the following, from the "Army and Navy Gazette" will be of interest. For some time the Ordnance Select Committee has ceased to exist, and few will regret its demise. It had many enemies, and was regarded with suspicion even by those to whom it was most favorable. It was confessedly an expensive body in itself, and was the cause and origin of much expense in experiments which were often supposed to be instituted more with a view to investigate the mathematical and theoretical value of inventions, than their practical utility to the service. Since the Ordnance Select Committee received its death-blow, the constitution of its successor has been much discussed, and several attempts have been made to arrange its composition. These have mostly proved abortive, but we believe that the future tribunals before which both inventors and inventions will be arraigned have been practically settled. The present committee which is engaged in investigating Captain Moncrieff's battery, and the proper emolument to be conferred upon its designer, will probably decide all broad questions of the same kind in future. This committee is composed of the Parliamentary Under-Secretary of State for War, the Comptroller-in-Chief, the Naval Director of Ordnance, the Director of Works, the Director-General of Ordnance and the Assistant-Director; and its province is to decide broad questions and general principles.

To carry out experiments and inquire into details, either a special committee will be assembled, as has been done in the case of deciding upon the new breech-loading rifle, and the armament of field artillery for India, or, in less important cases, the matter will be submitted to the consideration of a permanent committee of inventions. The committee of inventions will be for the present composed of Colonel Milward, R.A., C.B.; Colonel Shaw, R.A.; Colonel Wray, R.A. (late Bombay Artillery); Lieutenant-Colonel Heyman, R.A.; with Captain Harrison as secretary. By this reorganisation of the duties of the Ordnance Select Committee, a great improvement will be probably effected, and great dissatisfaction will be removed; for there is no doubt that, justly or unjustly, the late Ordnance Select Committee was suspected by the outside world to be composed too exclusively of officers of scientific tendencies, interested in inventions, who were not inclined to view with favor or even impartiality, inventions which did not originate among their own adherents. The new Ordnance Board will, however, be far above any such suspicion; and, as its members sit *ex-officio* it is almost certain to remain so. A tribunal will thus be secured which will be, if not always satisfactory to inventors, open to no suspicion of favor, partiality or affection, while the country will find in it an adequate, competent and inexpensive arbiter of what is requisite for its necessities, as the members will receive no additional emolument for their services in this capacity.

THE HOLYOKE DAM.—The dam across the Connecticut River at Holyoke, Mass., having an unbroken length of upwards of 1,000 feet and with the water pouring over it in a massive sheet with a fall of 30 feet, has long constituted one of the most noteworthy of the many objects of interest in that portion of the country. The picturesque aspect is, however, doomed to be done away with, for the wear of the waters upon the soft rock at the base of the dam has hollowed it out to a depth of from six to eight yards, thus endangering the foundations of the structure and necessitating repairs which amount practically to thorough reconstruction, and which will change the waterfall into swift rapids shooting down an artificial inclined plane.

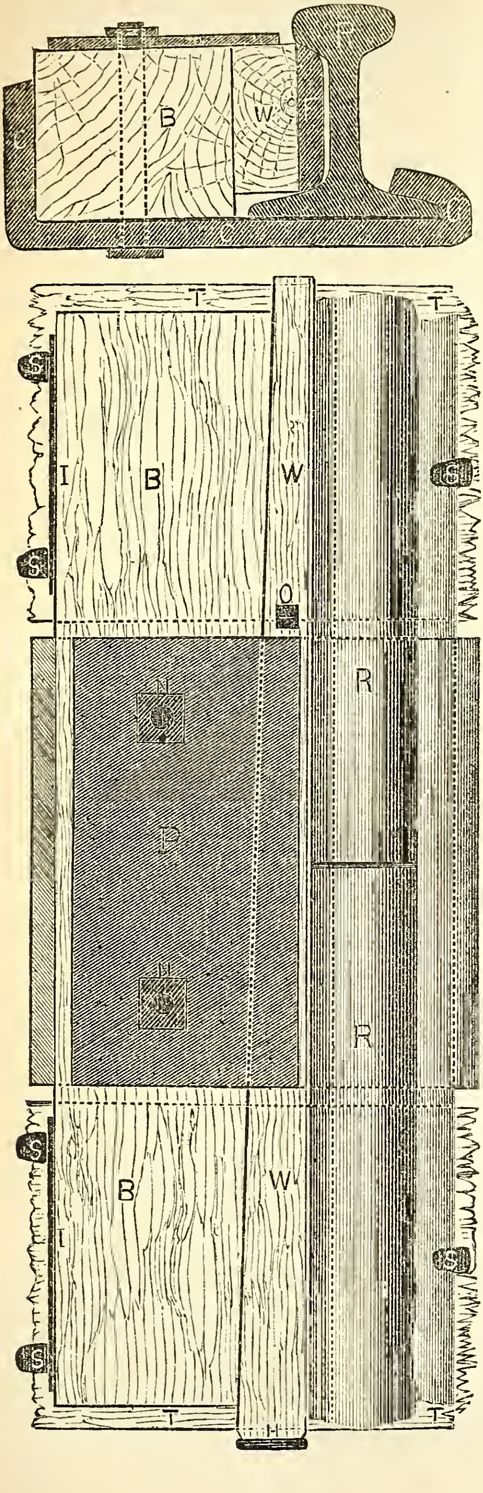
The process of repair is now being carried on with great energy, a portion 279 feet long at the centre of the dam having been already completed. For a distance of 50 feet down the stream, a series of timbers, locked and framed one over another, have been laid, and their interstices filled with stone. These from the bed of the stream rise to a height of twenty-five feet to the surface of the water. From the front edge of the substructure thus formed, the frame-work is continued with an inclined surface until it reaches the crest of the dam 30 feet above. This solid mass of stone and timber is covered with square logs a foot in diameter, and pinned fast to the timbers underneath; upon these are spiked maple planks four inches thick, which make the covering for the whole. The crest of the dam for a width of five feet is designed to be covered with three-sixteenths boiler-plate, of which not less than sixteen tons will have been used by the time the work is finished.

The portion or section of the dam of which we have just spoken has alone required about one million feet of lumber, eight thousand square rods of stone, and fifteen tons of bolts. The weight of the entire structure is estimated at thirty-three tons. The weight of that part of the dam is capable of resisting about four times the ordinary pressure of the water upon it.—*American Artisan.*

JAMES CHALMERS.—If the inventor of the best system of armor plating, could have enjoyed, while he was toiling for a trial of his scheme, a little more of that good English feeling and appreciation that the London newspapers are bestowing now that he is dead, it would have been better for all concerned. The system of backing armor plates by a cell-work of thin wrought iron plates, first introduced by Mr. Chalmers, has been improved only in size and detail, and is now the principle upon which every successful target is constructed. Mr. Chalmers' first target was not constructed at Government expense, but at the expense of Sir S. M. Peto. After its successful trial, says the "Army and Navy Gazette:" Mr. Chalmers suffered the mortification of seeing many of the essentials of his inventions copied and embodied in the recent additions to the Navy, without either acknowledgment or compensation; and, notwithstanding all his endeavors, he was never able, till lately, to prevail on the Government to get another target built embodying his invention, to be tried against a Government one of the same size and weight of metal. In this, careworn and wearied by official obstructions and delays, his naturally strong constitution gave way, and during the last eighteen months his health had been far from good, till at last he died on the 26th of December, at his residence in London.

Mr. Chalmers was also the author of a scheme of sunken channel railway, between England and France. His plan was, to have a tube of boiler plate, lined with brick, laid on the bottom of the sea, with ventilating towers at intervals; and the pamphlet which he published on the subject attracted general attention, and no small amount of criticism at the time.

FOSTER'S RAIL JOINT.



Now that the subject of maintaining the continuity of rails, is receiving general attention in this country, we shall publish from time to time, the particulars and results of such new devices as have been well tested, or are obviously practicable.

The joint fastening shown in the cuts, is the invention of Mr. Foster, Superintendent of the Logansport, Peoria and Burlington railway. It has grown out of his observation of the remarkable wear of several pieces of track which had to be laid in a peculiar manner owing to local causes; the rails were practically sandwiched at the joints, and have outworn several similar rails laid in the common manner. About ten tons of these joints have been under practical test during two years past on the road mentioned, also on the Chicago and Great Eastern, upon tracks used in common by the several roads centering at Logansport, also upon sidings where a large amount of shifting is done; locomotives run over the joints 200 to 300 times per day. The results are extremely satisfactory, when compared with all forms of chairs; the report does not state, however, whether it has been compared with the best of the modern fastenings. The lateral as well as the vertical continuity of the track is well preserved. A great saving in repairs is clearly shown. No stops, O, have been placed upon the wedges, but out of the whole ten tons, but two have got loose. Experiments have shown that the joint has less deflection under a passing load than the solid rail.

The most economical and effective form of splice, when the rail is suitably shaped, is the fish bar between the head and flange. How to keep the fish bar tight, has taxed the ingenuity of inventors for some twenty years. In this case, it is held up to the rail by an oak wedge, W, bearing upon the whole face of the fish bar, and hence not likely either to mash or to slip. With a rail of the form shown (in distinction from the low "pear head"), and a stiff clamp, C, the fish is certain to remain tightly wedged between the tables of the rail, and to be fully utilized. The lip of the clamp C is also wedged tightly upon the flange of the rail by the same wedge that secures the fish plate, thus realizing in some degree the advantage of the new Reeves' joint, which is a tight clamp upon the flanges of the rail. The clamp C and the wooden longitudinal B also add a considerable resistance to deflection; but the chief office of the longitudinal is to form a backing for the wedge. The joint is suspended between two sleepers, thus giving ample elasticity, and also preventing the "creeping" of the track. Ths wood (oak) is seasoned, soaked in oil, planed, and carefully adjusted.

The best feature of this joint is the security of the fastening—the long wedge will not slip, though it may be readily set up; and its strength is a simple question of size of wedge and longitudinal. The joint is adapted to every form of rail, and may thus improve tracks that cannot be fished to advantage. It is well adapted to steel rails, because it requires no nicking or punching of the rails, either to prevent "creeping" or to hold the fish bar in place.

Iron Architecture.—From a historical article on this subject in "Engineering," we gather the following facts: In 1783 Robert Ransome patented the application of cast iron, variously ornamented, to roofs. Twenty-five years later, Ralph Dodd obtained a patent for applications of iron to floors and to ship work, including hollow columns. Several patents followed for the substitution of iron for timber work. In 1811 Thomas Pearsall patented the use of iron skeletons—standards, joists, &c.—to be filled in with brick work. Ten years later iron beams were first employed for fire-proof floors, at a cotton mill in Manchester. In 1834 Pearsall's iron skeleton, covered with iron sheets, was applied in the erection of a gas works in London; and in 1842 Messrs. Laycock, of Manchester, constructed an iron palace, fifty feet by thirty feet, and three stories high, for the King of Eyamba, on the Calabar river. About this time Messrs. Gussell were making iron buildings for erection abroad; iron frames and corrugated sheet-iron covering, and shortly afterwards, the manufacture of portable iron houses largely increased. In 1845, Mr. W. Vose Pickett formed a company to erect iron buildings, and was the first to advocate the use of the cellular form of construction, and the ornamentation of pannels to resemble stone. But with the exception of the Great Exhibition buildings of 1851 and 1862, and a few large structures for special purposes, and some mere sheds without ornament, the use of iron for building—for street architecuture—has been singularly neglected in England.

In the United States, on the contrary, thousands of iron structures have been erected, and such is their design that iron façades can hardly be distinguished from stone. The first of these buildings was put up by Daniel D Badger, of New York, in 1842. In the following year A. L. Johnson, of Baltimore, introduced revolving iron shutters, and by a combination of these with iron posts, the lower stories of commercial buildings came to be generally made of the new material. About this time James Bogardus, of New York, was working succesfully in the same direction, and in 1847 he erected his lofty iron factory, which was subsequently taken down and re-erected, on account of the widening of a street. The Architectural Iron Works of New York and other American cities, are now very numerous, one of the latest and most prosperous being a branch of the Novelty Iron Works. Some 150 iron buildings appear in Broadway, and the use of this material appears to be largely increasing.

The Leavenworth Bridge.—A contract for the construction of a bridge over the Kansas river at Leavenworth, has been definitely concluded with that eminent bridge builder, L. B. Boomer, Esq. The bridge is to be completed for both railway and highway traffic in twelve months, at a cost of three-quarters of a million of dollars. The main bridge will consist either of three spans of 340 feet each, or four spans of 258 feet each, the superstructure to be of iron, upon the plan known as the "Post's Patent Inflexible Truss." The west abutment will be of first-class masonry; the rest of the substructure of cast iron pneumatic piles or cylinders, each $8\frac{1}{2}$ feet in diameter, to be driven to the rock (about 60 feet below low water mark,) and carried up to the bridge seat, the whole height from rock to bridge seat being about 135 feet.

These columns are to be filled with cement and will be thoroughly braced to each other, and each pier will have an iron ice-breaker supported by another cylinder driven to the rock and brought up to low water mark. The approaches (about 4,000 feet long,) are to be built of wooden trestles.—*Chicago Railway Review.*

EXPERIMENTAL RESEARCHES ON THE MECHANICAL PROPERTIES OF STEEL.

By Wm. Fairbairn, L.L.D., F.R.S., &c.

From the "Quarterly Journal of Science."

The present may be justly considered the age of iron, as in every branch of industry where force, form, and motion are required, iron enters largely into construction, and its powers of application have supplanted almost every other material. It presents wonderful facilities in its adaptation to every description of art, whether of the useful or decorative style ; and its improved tenacity, elasticity and ductility have enlarged its field of usefulness in the construction of buildings, ships, steam-engines, bridges, and machinery of all sorts where strength combined with lightness is required. To this powerful and valuable material we are indebted for railways, locomotives, and rolling stock ; and there is no branch of manufacture in which it does not form a whole or a prominent part. Possessed of such a material in its cheapest and best forms, we should be deficient in duty if we left it in the rude state in which it was found in the days of Cort and his immediate successors. That great improvements have been effected of late years does not admit of doubt, and there is probably no material that has undergone greater changes in its manufacture than iron ; and judging from the attempts that are now making, and have been made, to improve its quality and to enlarge its sphere of application, we may reasonably conclude that it is destined to attain still greater advances in its chemical and mechanical properties. The earliest improvements in the process of the manufacture of iron may be attributed to Cort, who introduced the process of boiling and puddling in the reverberatory furnace, and those of more recent date to Bessemer, who first used a separate vessel for the reduction of the metals, and thus effected more important changes in the manufacture of iron and steel than had been introduced at any former period in metallurgic history. To the latter system we owe most of the improvements that have taken place ; for by the comparatively new and interesting process of burning out the carbon in a separate vessel, almost every description of steel and refined iron may be produced. The same results may be obtained by the puddling-furnace, but not to the same extent, since the artificial blast of the Bessemer principle acts with much greater force in depriving the metal of its carbon, and in reducing it to the state of refined iron. By this new process increased facilities are afforded for attaining new combinations, by the introduction of measured quantities of carbon into the converting vessel, and this may be so regulated as to form steel or iron of the homogeneous state, of any known quality.

The production of iron and steel in the homogeneous state is one of the most important improvements that has taken place since the process of rolling direct from the reverberatory furnace. The former process was first to melt the iron as it came from the smelting-furnace in the shape of pigs, to puddle it or to stir it about until the mass took the form of a ball deprived of its carbon ; it was then placed under the hammer, and formed into slabs or ingots The next process was to roll it into bars, which being cut into short pieces, were again heated and rolled either into plates or bars as required.

Now the great defect of this process was the unsound state of the iron, as the least rust or scoriæ on the surface of the piled bars prevented the welding or fusion of the metals, and hence followed what are called blistered plates, or laminated bars of unsound construction.

The new process, it will be observed, obviates all these difficulties, as in the Bessemer process the melted iron is deprived of its carbon by the action of an artificial blast—the same as formerly prevailed on the hearth of the refinery—and thence it is cast into ingots of the weight required, either for the hammer or the rolls. From this it will be seen that the risk of piling and welding is entirely dispensed with, and the article produced, whether of iron or steel, is perfect in its homogeneity. It may be of good or inferior quality, hard or soft, but by this process it is free from the risk of being unsound in its homogeneous state.

As regards the steel, of which we have to submit the results, as produced by the principal manufacturers of this country, it will be observed that in making steel from the puddling-furnace, similar combinations may be produced, but with less certainty as regards quality, as everything depends on the skill of the operator in closing the furnace at the precise moment of time, before the mass is deprived of its carbon. This precaution is necessary in order to retain the exact quantity of carbon in the puddled ball, so as to produce by combination the requisite quality of steel. It will be observed that in the Bessemer process this uncertainty does not exist, as the whole of the carbon is volatilized or burnt out in the first instance; and by pouring into the vessel a certain quantity of crude metal containing carbon, any percentage of that element may be obtained in combination with the iron, possessing qualities best adapted to the varied forms of construction to which it may be applied. Thus the Bessemer process is not only more perfect in itself, but admits of a greater degree of certainty in the results than could possibly be attained by the mere employment of the eyes and hands of the most experienced puddler. Thus it appears that the Bessemer process enables us to manufacture steel with any given proportion of carbon, or other eligible element, and thus to describe the compound metal in terms of its chemical constituents.

Important changes have been made since Mr. Bessemer first announced his new principle of conversion, and the results obtained from various quarters bid fair to establish a new epoch in metallurgic manipulation, by the production of a material of much greater general value than that which was produced by the old process, and in most cases of double the strength of iron.

These improvements are not exclusively confined to the Bessemer process, for a great variety of processes are now in operation producing the same results, and hence we have now in the market homogeneous and every other description of iron, inclusive of steel, of such density, ductility, etc., as to meet all the requirements of the varied forms of construction.

The chemical properties of these different kinds of steel have been satisfactorily established; but we have no reliable knowledge of the mechanical properties of the different descriptions of homogeneous iron and steel that are now being produced. To supply this desideratum, I have endeavored, by a series of elaborate experiments, to determine the comparative values of the different kinds of steel, as regards their powers of resistance to transverse, tensile, and compressive strain.

These experiments have been instituted not only for those engaged in the constructive arts, but also to enable the engineer to make selections of the material as will best suit his purpose in any work proposed. In order to arrive at correct results, I have applied to the first houses for the specimens experimented upon, and judging from the results of these experiments, I venture to hope that new and important data have been obtained, which may safely be relied upon in the selection of the material for the different forms of construction.

For several years past, attempts have been made to substitute steel for iron, on account of its superior tenacity in the construction of ships, boilers, bridges, etc.; and there can be no doubt as to the desirability of employing a material of the same weight and of double the strength, provided it can at all times be relied upon. Some difficulties, however, exist, and until they are removed it would not be safe to make the transfer from iron to steel. These difficulties may be summed up in a few words, viz: the want of uniformity in the manufacture, in cases of rolled plates and other articles, which require perfect resemblance in character, and the uncertainty which pervades its production. Time and a close observation of facts in connection with the different processes will, however, surmount these difficulties, and will enable the manufacturer to produce steel in all its varieties with the same certainty as he formerly attained in the manufacture of iron.

In the selection of the different specimens of steel, I have endeavored to obtain such information about the ores, fuel and process of manufacture as the parties supplying the specimens were disposed to furnish. To a series of questions, answers were, in most cases, cheerfully given, the particulars of which will be found in the experimental tables, published in the Transactions of the British Association for 1867.

I have intimated that the specimens have been submitted to transverse, tensile, and compressive strain, and the summaries of results will indicate the uses to which the different specimens may be applied. Table I. gives for each specimen the modulus of elasticity, and the modulus of resistance to impact, together with the deflection for unity of pressure; from these experimental data the engineer and architect may select the steel possessing the actual quality required for any particular structure. This will be found especially requisite in the construction of boilers, ships, bridges, and other structures subjected to severe strains, where safety, strength, and economy should be kept in view.

In the case of transverse strain some difficulties presented themselves in the cours of the experiments, arising from the ductil .

nature of some part of the material, and from its tendency to bend or deflect to a considerable depth without fracture.

But this is always the case with tough bars, whether of iron or steel, and hence the necessity of fixing upon some unit of measure of the deflections, in order to compare the flexibility of the bars with one another, and, from the mean value of this unit of deflection, to obtain a mean value of the modulus of elasticity (E) for the different bars. This unit or measure of flexibility given in the table, is the mean value all the deflections corresponding to unity of pressure and section. In order to determine the resistance of the bars to a force analogous to that of impact, *the work* in deflecting each bar up to its limit of elasticity has been calculated. These results differ considerably from each other, showing the different degree of hardness, ductility, etc., of the material of which the bars are composed. The transverse strength of the different bars up to their limit of elasticity is shown by the amount of the *modulus of strength* or *the unit of strength* calculated for each bar.

Table II, on Tensile Strain, gives the breaking-strain of each bar per square inch of section, and the corresponding elongation of the bar per unit of length, together with the ultimate resistance of each bar to a force analogous to that of impact.

Table III, on Compression, gives the force per square inch of section requisite to crush short columns of the different specimens, with the corresponding compression of the column per unit of length, together with the work expended in producing this compression.

It will be observed from the following tables that the results of the experiments show that the deflections produced by a transverse strain are in proportion to the pressures within the limits of elasticity.

In Table I, as in the other two on tension and compression, the value of the work done on each specimen has been determined, and the results recorded in the last column indicate the comparative strength of each particular bar; and the mean value of the deflections corresponding to unity of pressure and section will be found in column 3. These may be taken as the measure of flexibility, elasticity, and ductility of the different bars, and the uses to which the material may be applied.

The mean value of E, the modulus of elasticity taken for thirty of the best specimens, is about 31,000,000, which exceeds that of wrought iron by more than the thirtieth part. Steel having a much greater flexibility than malleable iron, accounts for the approximation of their respective values in D. This arises from the fact that the bars of the greatest flexibility—other things being the same—have the least value for the modulus of elasticity.

On tensile strain the mean result derived from thirty of the best specimens is 47.7 tons, or nearly 48 tons per square inch; and in this, as in the previous table, the measure of ductility and strength is given in the last column, which indicates the ultility of the material and the purposes for which it may be selected.

Comparing the best quality of steel with the best wrought iron at 24 tons as the breaking-weight per square inch, we find that we have a material of double the strength with the same weight, or what is the same thing, of only half the weight with the same same strength, or as 47.7 to 24. In the art of construction these are considerations of great importance; and in every case where steel can be depended upon, it is entitled, on the score of economy and lightness, to the judgement and practical knowledge of the architect and engineer.

In Table III, on compression, each of the specimens were reduced, when cut from the bars previously experimented upon, to small columns of $\frac{3}{4}$ inch diameter and 1 inch in height. They were each loaded with weights equal to 100 tons per square inch, without undergoing any sensible appearance of fracture. On consulting the table it will be found that with the above weight of 100 tons per square inch they were compressed, on the average, to two-thirds their original length; and from these facts we were enabled to find the value of u, recorded in the last column, as the value of work done by the load which produced the change of form in each of the specimens submitted to pressure. This, it will be observed, was the true test of the powers of resistance of the respective specimens to a compressive strain, and the conditions under which materials of similar properties may be safely applied in constructive art.

On comparing the mean tensile resistance to rupture at 47.7 tons per square inch, it will be seen that the resistance to compression is more than double the resistance to extension, or as 100.7 to 47.47, being in the ratio of near 2:1. Hence it follows that the most economic form of a steel bar un-

Comparison of Steel Manufactured after the Bessemer Process with that Manufactured by other Processes.

Table I.—*Transverse Strain on Inch-square Bars, and 4 ft. 6 in. Between the Supports.*

MANUFACTURER.	Description of steel.	Mean value, D_1, of the deflection for unity of pressure and section.	Mean value of the modulus of elasticity E.	Mean work of deflection, *u*, for unity of section.	Mean value of C, the unity of working strength.	Remarks.
					Tons.	
Messrs. J. Brown & Co...	Bessemer steel,	·0012739	30,730,000	52·721	5·918	Mean breaking weight, 1,000 lbs.
Messrs. C. Cammell & Co.	Bessemer steel,	·0013518	29,166,000	59·897	5·921	Mean breaking weight, 950 lbs.
Messrs H. Bessemer & Co.	Bessemer steel,	·0016684	29,813,000	49·489	5·659	Mean breaking weight, 975 lbs.
The Hæmatite Steel and Iron Company.........	Bessemer steel,	·0014590	27,153,000	26·463	3·914	Soft steel.
Mean...............	....	·0014382	29,215,000	47·142	5·283	
Messrs. Naylor, Vickers & Co	Melted in the crucible	·0013007	30,278,000	65·049	6.548	
Messrs. S. Osborn & Co..	Melted in the crucible	·0014296	27,482,000	52·574	5·622	Mean breaking weight, 1,250 lbs.
Messrs. C. Sanderson & Brothers	Melted in the crucible	.0013209	29,973,000	47·411	5·521	Mean breaking weight, 1,250 lbs.
Messrs. T. Turton & Sons,	Melted in the crucible	·0013120	30,294,000	52·680	5·886	Mean breaking weight, 1,200 lbs.
The Titanic Steel and Iron Company.........	Mushet's steel,	·0012350	31,901,000	63·542	6·435	
Mean...............	....	·0013196	30,042,000	56·251	6·002	

Table II.—*Tensile Strain on Bars ¾ inch Diameter—Elongations Taken on 8 in. Length.*

MANUFACTURER.	Description of steel.	Specific gravity.	Mean weight laid on in lbs. producing rupture.	Mean breaking strain per square inch of section. Lbs.	Tons.	Mean elongation, per unit of length.	Mean value of *u*, or work produc'g rupture. By eq. 13.
Messrs. J. Brown & Co..	Bessemer steel........	7·7665	33·603	90,379	40·35	·0460	2002
Messrs. Cammell and Co.	Bessemer steel........	7·8119	34·085	101,132	45·14	·0595	2714
Messrs. Bessemer & Co...	Bessemer steel..	7·7726	38·189	89,955	40·15	·0753	3212
The Hæmatite Steel and Iron Company	Bessemer steel........	7·7951	33·321	72,195	32·22	·0942	3351
Mean...............	....	7·7891	34·299	88,415	39·46	·0682	2819
Messrs. Naylor, Vickers & Co......	Melted in the crucible,	7·8198	39·449	108,099	48·25	·0372	1827
Messrs. S. Osborn & Co..	Melted in the crucible,	7·7758	44·131	103,214	46·07	·0341	1842
Messrs. C. Sanderson & Brothers..............	Melted in the crucible,	7·7563	39·592	95,553	42 65	.0229	1566
Messrs. T. Turton & Sons,	Melted in the crucible,	7·7990	39·295	93,380	41·61	·0165	807
The Titanic Steel and Iron Company.........	Mushet's steel........	7·7883	37·179	93,616	41·79	·0551	2413
Mean..............	....	7·7878	39,923	98,772	44·07	·0327	1691

COMPARISON OF STEEL—Continued.

TABLE III.—*Compressive Strain on Specimens ¾ in. Diameter and 1 in. in Length.*

MANUFACTURER.	Description of steel.	Mean weight laid on in lbs.	Greatest weight laid on per square inch of section.		Mean compression per unit of length.	Mean value of *u*, or work expended in crushing the bar.
			Lbs.	Tons.		
Messrs. J. Brown & Co............	Bessemer steel........	91,840	225,568	100·700	·347	39,101
Messrs. C. Cammell & Co..........	Bessemer steel........	91,840	225,568	100·700	·339	38,232
Messrs. H. Bessemer & Co..........	Bessemer steel........	91,840	225,568	100·700	·379	42,720
The Hæmatite Steel and Iron Co...	Bessemer stlel........	91,840	225,568	100·700	·445	50,207
Mean........................	....	91,840	225,568	100·700	·377	42,981
Messrs. Naylor, Vickers & Co.......	Melted in the crucible,	91,840	225,568	100·700	·286	32,300
Messrs. S. Osborn & Co............	Melted in the crucible,	91,840	225,568	100·700	·267	30,014
Messrs. C. Sanderson & Brothers....	Melted in the crucible,	91,840	225,568	100·700	·328	36,906
Messrs. T. Turton & Sons	Melted in the crucible,	91,840	225,568	100·700	·398	29,254
The Titanic Steel and Iron Company,	Mushet's steel........	91,840	225,568	100·700	·315	35,551
Mean........................	....	91,840	225,568	100·700	·318	32,805

dergoing a transverse strain would be a bar with double flanges, having the area of the top flange about one-half that of the bottom.

This conclusion is borne out by the results of experiments on transverse strain, where S_1, the strain per square inch of the material at the elastic limit, $= 6\ C = 6 \times 6.83$ tons $= 40.98$, or 41 tons nearly; but the mean breaking-strain per square inch by extension $= 47.7$ tons, clearly indicates that the compressive resistance in the former case was considerably in excess of the tensile resistance.

It is important in every experiment on the strength of materials, which enters so largely into constructive art, that we should be thoroughly acquainted with the properties of the material of which the structure is composed, and that its resistance in all the different forms of strain should be clearly and distinctly ascertained. In the foregoing experiments we have determined the resisting powers of the different specimens to bending, tension, and compression; but we have omitted that of torsion, or twisting, until we have an opportunity of doing so upon the same identical bars. These I hope to accomplish at some future period, and also to give some further results upon an enlarged scale, calculated to confirm what has already been done, and to ascertain some additional facts in regard to the changes now in progress in the manufacture of Iron and Steel.

THE PNEUMATIC DESPATCH.

This thoroughly practical, speedy and cheap means of transporting parcels, if not passengers, having been placed under a temporary cloud by the financial difficulties of the London Company that are building it on the largest scale, is is about to be revived and pushed to completion. Says "Engineering": Some five years ago the Pneumatic Despatch Company commenced the construction of a line from Euston station to Holborn, and thence to the General Post-office. The first length, from Euston square to Holborn, was completed in the autumn of 1865, and in the October and November of that year many experimental trains were despatched through the tube with success. The experimental working, however, lasted for a weeks only, and eventually, pecuniary difficulties arising, the works were closed. Things remained in this state until a few weeks ago, when arrangements were made to complete the line. The length from the Euston station to Holborn is 1¾ miles, while a short length has also been laid from the Holborn station eastward, and this latter length is now to be extended to the General Post-office.

For the greater part of its length the line consists of cast-iron tubes 4 ft. 6 in. wide by 4 ft. high, these tubes being made in 9 ft. lengths, and the joints between them being caulked with lead. Besides curves of moderately large radius the line comprises a curve of 170 ft. radius, at the corner of Drummond-street and the Hampstead-road, a similar curve where the line turns eastward at Broad-street, St. Giles's, and a curve of 70 ft. radius where it enters the Holborn station. On these curves the tube is constructed of brickwork.

At the Holborn station are situated a pair of horizontal engines with 24 in. cylinders and 20 in. stroke, which work the fan 22 ft. in diameter, by which the air is exhausted from and forced into the tubes. The trains will be drawn from the termini to the Holborn station by exhausting the air in the tube, and forced from the Holborn station to the termini by the opposite process. The carriages, or trucks, are carried on four wheels, and their ends are shaped so that they almost fit the tube, the slight clearance allowed being partially closed by projecting strips of sheet india-rubber. The suction main is connected with each main tube at some distance from the end, and the carriages, on passing the mouth of the suction tube, have their motion arrested by the cushion of air formed between them and the doors, by which the end of the main tube is closed. At the proper moment these doors are opened by a self-acting arrangement, allowing the train to pass through. At the Holborn station the ends of the two main tubes, the one from Euston and the other (which is yet to be completed) from the Post-office are situated side by side, and a traverser is provided by which the trucks can be rapidly transferred from the one tube to the other. It is expected that the total time occupied in the transit from the Euston station to the Post-office will be about from 13 to 15 minutes; the time occupied by the experimental trains in running from Euston station to Holborn being 7 minutes.

Of the progress of a similar work in New York, the "New York Times" says that a company of English capitalists, have obtained a charter from the Legislature and have commenced to construct a pneumatic dispatch-tube in the lower part of the City, for the conveyance of parcels and letters, and it might be, passengers also. Mr. Moses Beach, the president of the company, hired the basement of the Messrs. Devlin's store, corner of Broadway and Murray-street, as a starting point for the line, with the intention of carrying it to the vicinity of the Nassau-street Post-office. The work of tunneling beneath Broadway then begun, has been slowly but steadily progressing, and will be pushed forward to completion as soon as possible. The details of the company have been carefully withheld from the public, in order to avoid the otherwise inevitable annoyance of injunctions from stage-line proprietors and property-owners on the route.

VIS VIVA.—"With a double velocity the moving (railway) train passes over double the space each second, and therefore encounters twice as many points of resistance. Moreover, it strikes each of these points with double the velocity, and hence meets at each point twice the resistance. It therefore meets, during a second, twice as many points of resistance, and suffers at each point twice as much resistance. The resistance, during a second, is thus four times as great as before, and must require four times as much force to overcome it. In order to obtain three times the velocity it would be necessary to increase by nine times the force; and in general the force required will be proportional to the square of the velocity to be obtained. What is true of the motion of the train of cars is true also of the motion of a steamboat through the water, and indeed of any motion on the surface of the earth, since all such motions encounter resistance. Hence the work accomplished by a force is proportional, not to the velocity, but to the square of the velocity, which it imparts to the moving body." (Cook's Chemical Physics, page 52.) Prof. Cook continues, upon such a basis, to explain *vis viva* and *momentum*. Most of the school-books on physics and natural philosophy present the subject in a similar way, and we have quoted from Cook's Chemical Physics simply because it is a work of the very highest repute for accuracy of statement of facts and theories, and therefore cannot be objected to as a representative.

In our present judgment the statements above quoted are not sustained by reason or experience. It is very far, indeed, from true, as a question of fact, that the power required to maintain a train or a ship in uniform motion varies as the square of the velocity; there is really no such mathematical relation, and there is no close approximation to it; moreover, the case of a ship is so different from that of the train that many engineers who strive to measure facts on a procrustean bed of simple mathematical formulæ, represent that the power required to drive a ship varies as the cube of the velocity; and no experienced engineer will say that within ordinary limits of speed four times as much power is ever required to maintain a train at double velocity. Professor Cook indeed represents that the resistances in a double velocity are doubled at each point, but this is surely an assumption, and is not warranted by experience. The resistances to a train in motion are mainly friction, and the air to be pushed aside; the friction is nearly proportioned to space and not to velocity, while a law of the resistance of the air is practically indeterminable. Now we have to suggest that the confusion and mystery of the subject, at least so far as the theory is concerned, are avoided by considering the work done as the measure of force or power. If we wish to determine only the *quantity* of effective force concerned in a movement, it is quite independent of time or velocity; the raising a pound of matter one foot implies always the same amount of moving force, power, or actual energy, whether it has occupied an instant or an age. Double work imples double power; to grind two bushels of corn requires twice the power to grind one. When resistances to motion are uniform, the space gone over measures the work and the power irrespective of time and velocity. If in any case the total quantity of resistance varies with velocity, then the power to maintain uniform motion will vary with the square of the velocity; but is there really such a case in nature or in art? A locomotive engine makes a certain number of strokes (excepting the slip) per mile, whether moving fast or slow. which represent the same number of cylinders full of steam, and, except for the resistance of the air, the cost per mile of running would be nearly the same for all velocities.

It should be noted that we carefully distinguish the cases of maintaining a uniform motion and the changing of velocity. In case of regular change (acceleration or retardation), as in the free fall of bodies by gravity, the spaces gone over are a measure of kinetic energy and vary with the square of the velocity; for example, to double the acquired velocity requires quadruple the power. It requires about four times the space and four times the steam to attain from rest a double velocity of a locomotive, but when the velocity is attained we have done with the ratio of the squares. The principle of *vis viva*, as we understand it, applies only to the changing of velocity.—*Chemical News.*

BREAKING IRON AND STEEL MASSES.

"Armengaud's Génie Industrille" through "Dingler's Polyt. Journal." Translated by John B. Pearse.

Pieces of cast iron of considerable size are extremely difficult to break up, and necessitate colossal air furnaces in order to melt them without breaking. The following method of breaking up large pieces has been practiced successfully at the works of Petin and Gaudet in Saint Chamond. Powder is often used to divide large masses, but aside from the necessary caution, its use is difficult and it often does not accomplish the desired effect. The following method, invented by M. Montandon, manager of the above works, is quite easy to apply, and not at all dangerous. It consists in using the force, which confined water exerts (when struck), in every direction upon the material in which it is enclosed.

A round hole two to three inches in diameter and ten to twelve inches deep is bored in the mass to be split; this hole is then filled with water and closed by a closely fitting steel cylinder upon which the drop is allowed to fall from the usual height. The mass is thereby split into several pieces, as if by a strong wedge with several faces. The water cannot escape and its endeavor to do so bursts the metal. In this way a plate roll of 29½ inches diameter was split, in presence of the French editor, into four or five pieces, which flew 20 to 30 feet away from the drop.

The hole must be hermetically closed and in order to do this thoroughly it is necessary to hollow out the base of the steel cylinder into a cup shaped form, the edges of which are driven against the walls of the hole by the water in its efforts to get past. To allow the air under the pin to escape, it is well to file a small screw-shaped grooved on the latter, when it can be driven down quite easily.

A single blow of an ordinary drop usually suffices to split off pieces of 30 to 36 inches in diameter. A pin of good steel can be used several times. This method is obviously easier than the use of a large drop falling a great distance and is much more certain in its effects.

SANITARY ENGINEERING.—In addition to watering and draining towns, the engineer is now called upon to provide fresh air artificially—to ventilate not only buildings, but whole towns. This subject was mentioned by Dr. Rumsey, in a recent address to the National Association for the promotion of social science, in England.

IRON AND STEEL NOTES.

INFLUENCE OF THE OXIDES OF CHROMIUM AND TITANIUM ON THE COMPOSITION OF PIG IRON.—Within the last four years we have been frequently employed in chemical investigations of the altered characters of some pig irons, which resulted apparently under the usual circumstances in the reduction of uniform ore. In these cases the amount of carbon united with the iron had been diminished, without the introduction of other matter in quantity sufficient to influence a change in this connection, and generally no variation in the composition of the ore was known or suspected. We had analyzed the ores in some of the beds in former years, and regarded them as well adapted to the production of pig iron of good quality; but, in pursuing the research, we were convinced that the change in quality of iron could be traced to altered composition in the ore of part of the beds used for supplying the furnaces.

The correctness of this view was confirmed by our analyses of many iron ores, in some of which we found the oxides of chromium or titanium, existing where they were not indicated and connected with the ore in beds which have been considered as pure iron ores. Both the oxide of chromium and oxide of titanium seem to act in the furnace or the crucible in a way to withdraw a portion of the carbon, or prevent that true union of carbon with a portion of the iron, which constitutes gray pig iron, without the metals of these oxides really alloying with the iron and thus indicating the cause of change. We have analyzed samples of pig iron where the alloys of chromium or titanium existed in the pigs, and where the oxides accompanied the ores in the beds, but we were not prepared to find an influence exerted on the quality of the pig metal *without the refractory metals forming a part of the composition.*

The occurrence of oxide of magneso with iron ore is common, and titanium compounds are often found in both magnetic and brown iron ores, as insoluble substances, in small proportions, and these compounds combine with and are removed by the fluxes without injury to the pig metal. These compounds of titanium are the cause of the often superb blue color of the cinder, produced under varying conditions of glassy or stony character, and must be carefully distinguished from those we regard as more detrimental in their influence on the metal.

In a number of analyses of iron ores we had found both oxide of chromium and oxide of titanium in a state rendering them soluble in diluted acids, and in a condition to escape detection in the ordinary modes of analysis. Both magnetic and brown iron ores have been found to contain either oxide of chromium or oxide of titanium in this soluble state. Among the samples from contiguous beds, this diversity in composition made by the presence of some oxide of chromium or oxide of titanium existed; and while the bulk of a bed of ore was pure, continuations of the bed, or associated ore, yielded notable weights of oxide of chromium or oxide of titanium in the different samples.

The suggestion we would make to the iron master in view of these facts is, the possibility of the quality of the pig metals in anomalous cases being greatly influenced by the admixture of some ore containing the oxides of chromium or titanium, with the basis ore of good quality. This may take place by the main bed being crossed by veins of mixed ore, or by the workings passing into contiguous beds where one kind of ore is used. In other cases, where the iron master can gain the great advantage arising from mixing ores, one of the kinds may contain the contaminating oxides and injure the iron.

We subjoin some results of analyses showing the proportion of oxide of chromium to tho metallic iron contained in the ore: 1st. Magnetic ore—iron, 49; oxide of chromium, 1·40. 2d. Hematite ore—iron, 42·47; oxide of chromium, 1·60. 3d. Brown Massive ore—iron, 64·32: oxide of chromium, 1·90. 4th. Same—iron, 46·70; oxide of chromium, 1·04. More traces have been discovered in some cases, while in other instances a larger proportion of chromium formed an alloy with the iron produced from the ore.—Aug. A. and S. Dana Hayes, Assayers to State of Massachusetts.—*Railway Times.*

MANUFACTURE OF IRON DIRECT FROM THE ORE.—At the Ringgold Iron Company's Works, in Pennsylvania, an improved process of manufacturing wrought-iron, the invention of Mr. J. Jameson, has for some time past been in successful operation. The furnaces are somewhat of an oven-shape, having, however, a stack from the top of about twenty feet in height. A refining fire is in front, into which the blast-pipes enter on the side. The gas that is evolved from the fuel passes into a chamber, where combustion takes place, and thence the combustion of the gases continues till above the fifth chamber it passes (together with such deleterious qualities as have been taken up from the ore in its progress) through and out of the stack. The five chambers are called in the Jameson patents the deoxidizing chambers. The ores are calcined, then crushed, and first placed in the top or fifth chamber. Into the first and second chambers a small jet of steam is injected, whereby hydrogen is generated for the purpose of aiding in desulphurizing and dephosphorizing the ores. The floor of the top chamber is a table made of fire-clay blocks, with an opening at the end opposite from the door or entrance through which the raw ore is thrown in. On this table the ore is spread out, and after being subjected to the operation of the burning gases, it is then pushed down through the opening at the end of the table opposite to the door on to a like table in the chamber below, where it is again spread out, and here it remains for a time and in like manner passes on to the table of the third chamber; there, after undergoing a like operation, it is passed to the second chamber, thence it goes to the bottom or the first chamber. Thus every particle of the ore is equally operated upon. By this time the ore is almost a pulp, and then it is passed into the charcoal bed and refining chamber. Here the loop is soon formed, when it is taken out, and the hammer soon presents you with a bloom of from 225 to 250 lbs. weight. It is well known that the blooms produced by the direct processes are of inferior quality, whilst a very large quantity of ore and fuel is used in their production. With the Jameson process these difficulties are avoided—a ton of blooms being produced with the same quantity of ore and fuel as is now employed to make a ton of pig metal in the blast furnace. The production is stated to be unfailingly uniform.—*Mining Journal.*

CASTING STEEL UNDER HIGH PRESSURE by means of gunpowder, is thus described by the inventor: It is well known that cast steel run into moulds is subject to blister and is otherwise porous, which defect reduces considerably its toughness. In order to give this metal its requisite tenacity it is subsequently re-heated and then rolled or hammered. As many articles, such as cannon, cannot be treated in this manner, I have devised to submit them to a high pressure whilst in a liquid state, enclosed in their same moulds, maintained in iron flasks. For this purpose, immediately after running a cannon, I cover hermetically the head by a metallic cap, by means of bolts or other devices attached to the flask. This cap is fitted in its center with a vertical pipe, and provided with a cock at its lower extremity, whilst its upper extremity is closed by a washer pressed by a bolt in such manner as to act as a safety valve. Before attaching the cap, at, supposing, one inch from the surface of the liquid metal, I introduce in the vertical pipe, and between the cock and the washer, a charge of about one quarter of an ounce of a powder, prepared in the proportions of eighty parts of saltpetre and twenty parts of charcoal. On opening the cock this powder falls on the metal, ignites and engenders about one-third of a cubic foot of gas at 3,000 Fahr. These gases exert on the liquid metal a pressure which is transmitted throughout the entire mass, thereby condensing the same and expelling the blisters. The effect thus produced is equivalent to the pressure of a head of liquid metal ninety feet high, admitting that the capacity between the cap and the surface of the metal contains thirty cubic inches. By making the flasks sufficiently strong, the charges of the powder may be varied, so as to produce by its ignition a uniform and general pressure, which is preferable to the partial, irregular and momentary action of a hammer.

New Blowing Engines for the Wigan Coal and Iron Company.—These engines blow air into ten blast furnaces, through a wrought iron tube seven feet in diameter, the blast being delivered at a pressure of about four pounds to the square inch. Before entering the furnaces, the blast is heated to from 800 to 1,000° Fahr. The furnaces have closed tops, in the usual manner. To each furuace there are four hot blast stoves. The present number of boilers put down is ten, double-flued and ranged in front of the engine house, which is a magnificent structure, with a tower at least 100 feet in height. The machinery is from the works of Messrs. Nasmyth, Wilson & Co., of Manchester. There are three engines, with six blast cylinders, and six high and low pressure steam cylinders. The diameter of the air cylinders is 100 inches; of the high-pressure steam cylinders 45 inches; and of the low-pressure steam cylinders 66 inches. The stroke of each engine is 12 feet. All the steam cylinders have steam jackets; also the exhaust pipes between the high and low pressure cylinders. The engine beams are 36 feet from center to center. Each pair of engines has two blowing cylinders; each blowing cylinder is above each steam cylinder. The engines being worked by high and low pressure, the high cylinder is connected with the low one by two side levers and beams, already referred to. The working apparatus is in duplicate, worked from one end, so that both cylinders are worked by steam valve gear; this valve gear is worked by an entirely new motion, patented by Mr. Robert Wilson. The air to supply the blast is conveyed into the engine house through a tower and an underground tunnel.

Iron and Steel Institute for Great Britain. — At the preliminary meeting of this organization lately held in London, Mr. Isaac L. Bell, of Middleboro', in the chair, it was resolved to ask tho Duke of Devonshire to be the first president, 1st, because Englishmen are very fond of having a nobleman at their head; and, 2d, because the Duke, in addition to having great possessions in mineral property, is at the head of a concern which is amongst the foremost and the most extensive of modern iron and steel works in England.

The following subjects wero suggested as proper for the consideration of the Institute:

Iron Ores.—Details of newly discovered deposits of iron ores; analyses of various English and foreign ores; mode of occurrence; cost of working; probable extent of deposits; distribution of ores; ironstone mining.

Blast Furnaces.—Calciniug kilns; use of furnace gases for calcining; blast furnaces—modes of construction; best proportions of various classes of minerals to be used; engineering arrangements; blowing engines; hoists; utilization of furnace gases and furnace slag; heating stoves; tuyeres; casting arrangements; generation of steam; construction of chimneys.

Conversion of Pig into Wrought Iron.—Improvements to save expense of re-heating pig-iron; improvements in puddling and heating furnaces; fettling; mechanical puddling; simplification of converting processes; methods of arranging forges most effectively; utilization of waste heat from furnaces; selection of materials for different classes of finished iron; mill work; arrangement of different kinds of mills; details of manufacture of rails, plates, bars; special sections; new application of iron.

Foundry Work.—Special qualities of various kinds of pigs; cupolas; improvements in melting furnaces, and in arrangements for moulding with rapidity and certainty; testing iron.

Steel.—Relative merits of various plans for the production of steel; manipulation of cheaper brands of iron for steel making; applications of steel.

Metallurgy.—Solution of numerous disputed points in connection with the metallurgy of iron and steel; verification of Bunsen's and Playfair's experiments; improved methods of practical and expeditious analyses of iron; purification of iron from deleterious elements; further examination of the properties of the alloys of iron; influence of magnetism upon iron and its alloys at various temperatures.

Miscellaneous.—Statistics of the position and development of the iron and steel manufacture in this and other countries; reports on special features of foreign iron-fields and iron and steel works.

Philadelphia and Reading Railroad Company's Rolling Mill. — This mill is eligibly situated about two miles north of the Reading City passenger station, at the point where the East Pennsylvania railroad diverges from the main trunk. The mill-house is 413 feet in length by 93 feet in width, with a spacious wing projecting from one side. There are twelve puddling furnaces, eight heating furnaces and two re-heating furnaces. There are two trains of 23-inch three-high rolls. The finishing train is two-high. The rails rolled are of three weights—64 pounds, 62 pounds and 56 pounds per yard—for use in localities according to character of traffic. The rails contain about one-third part new iron.

The housings and bed-plates of the trains were made by Matthews & Moore, of Philadelphia, and are not only heavy and strong, but very accurately fitted. This accuracy of workmanship, such as characterizes the best marine engineering, is new, but equally important in rolling mills, and is a feature of Matthews & Moore's work to which we have previously referred in speaking of their machinery at the Pennsylvania Steel Works, and at the Abbott Mill in Baltimore. The saw machinery of the Reading mill is by the same builders. The engines are by George W. Snyder, of Pottsville, the work being surpervised by J. E. Wootten, Engineer of Machinery for the P. & R. R.R. Co. All the boilers, castings, furnaces, &c., were made at the company's shops in Readiug. The general plan, and the details of the parts not otherwise specified above, were made by Mr. W. E. C. Coxe, and the whole was erected under his superintendence, and is run under his able management. The carrying out of Mr. Coxe's plans was entrusted to Mr. Samuol Stroh, the present foreman of the mill.

The capacity of the mill was recently tested as follows: During twelve hours, $92\frac{1}{2}$ tons (2,240 lbs.) of rails (405 bars of 64-lb. rails) were produced from eight heating furnaoes; theso were all heated a second time after blooming in two re heating furnaces, giving an average of $46\frac{1}{4}$ tons for each of the latter. The product of the mill in January was 1,437 tons of finished rails.

GALVANISING IRON.—DRAWING OFF THE OFFENSIVE VAPORS.—The application of zinc with tin as a coating for iron, has become a most important manufacture in and about Birmingham. The application of iron for every purpose of construction is practically only limited by the difficulty of preserving the surface from rust. No method has yet been adopted which is at once so cheap, so effectual, and so enduring as galvanizing, and the works in which that process is carried on have very rapidly increased. To galvanise iron it is immersed for a certain period in an acid to cleanse the surface, after which it is dipped into a bath containing zinc and tin melted. In this salts of ammonia are thrown, which operates on the metal as a solvent, and enables it to be more evenly distributed over the surface. From this bath is given off a dense, pungent, white-colored vapor, which is heavy, and, especially in damp weather, spreads and becomes offensive. Complaints have been made of these vapors, and various plans have been adopted for the purpose of preventing them from passing into the atmosphere, but heretofore without success. The Wolverhampton Corrugated Iron Company have adopted a plan which is found very effectual. The top of the bath is surrounded by a flue which forms a projecting lip, and from this run one or more iron pipes communicating with a powerful fan. From the fan a large flue extends to an annealing furnace. The fan, by creating a vacuum in the pipes, causes a strong current of air to pass over the surface of the bath, which drives the vapor into the furnace, where it is entirely consumed. Experiments are in progress to condense the vapors so as to utilize them, instead of consuming them in fires.

CLEVELAND ROLLING MILL.—The works of this company were first established in 1857 for the manufacture of railway and merchants' bar-iron, since which time their capacity has been constantly increased. In 1859 the first blast furnace was built; afterwards, in 1864, the mill of the Railroad Iron Mill Company was bought and furnished with new machinery, and a second blast furnace erected. The two furnaces are now making from 45 to 50 tons per day, and the two rail mills have a capacity of 35,000 tons of rail per annum. The bar iron mill is capable of making from 12,000 to 14,000 tons per year. The company commenced the manufacture of Bessemer steel in September, 1868, with one five-ton converter, and are at present turning out some fifteen tons per day. They are now putting up another five-ton converter and erecting reverberatory furnaces and cupolas, which will enable them to increase the capacity of steel production from 40 to 50 tons per day. The greater portion of the steel has been made into rails, which have thus far shown the best results. The Bessemer steel made by this company has been very even in quality. The works are situated near the best iron-producing region of the country—the Lake Superior region—the ores of which are remarkably well adapted for producing steel by the Bessemer process. Besides turning out steel and iron rails of good quality, they manufacture beams, girders, merchants' bar, boiler rivets, fish plates, spikes, nuts, bolts and a variety of other articles used in railway construction and repairs. The works are favorably situated, having water and rail connections with the whole west and northwest.—*American Railway Times.*

FIBRE OF WROUGHT IRON.—In a paper read before the Liverpool Polytechnic Society, "On the Structure of Metals," Mr. Vivian stated that the "fibre" or "silky lustre" exhibited in the fracture of good iron is only the effect of the light reflected from inner surfaces of myriads of minute cells exposed by the fracture, that the form of these in their normal state is spherical, or nearly so, but they become changed in the process of rolling, &c. Air has no access to these cells in their concealed state, but when they are exposed to the action of the atmosphere they soon become tarnished. The cellular construction is not an accidental occurrence, but it is the proper constitution of the metal, and appears to take place under the combined effects of heat, the repellent force, and the coherent force inherent in the substance. The mechanical properties of tenacity, ductility, &c., must greatly depend on the perfection of the cell system, and as much importance should be attached to this as to the degree of chemical purity necessary to insure a good iron, since it is well known that from iron of the same chemical purity various qualities of metal may be produced by working at an improper temperature, or by cooling too suddenly.

PLANT AND OPERATIONS AT FIRTHS' STEEL WORKS.—Dr. Percy thus refers to the works of Messrs. Firth & Sons, of Sheffield, in a letter to the London "Times:" For casting large ingots each crucible contained about 50 lb. of molten steel. At a given signal the pouring of the metal commenced, and in sixteen minutes the ingot mould had received the contents of the 212 crucibles. There was no bustle or confusion. The men, 200 in number, knew their drill, and did their duty without a hitch. The ingot weighed 86 cwt., and was designed for the steel tube of an Armstrong gun. The receptacle employed by Krupp for receiving the steel from the crucibles, in the first instance, was dispensed with; but that is only a point of minor detail. The Messrs. Firth have cast nine-ton and sixteen-ton ingots. A nine-ton ingot is required for the 23-ton Armstrong gun. Messrs. Firth have expended about £30,000 in the erection of two 25-ton Nasymth hammers, re-heating furnaces, on Siemens' principle, and other appliances. The anvil block of each hammer is cast iron, cast in one piece, and weighs 164 tons. The length of hammer stroke is nine feet six inches.

THE SIEMENS FURNACE is being somewhat extensively applied for puddling, and so far as has been reported, with good results, there being not only a saving of fuel, but a very considerable saving of iron, while also the balls, especially if fettled in rich ore, are of better quality. The importance of the highest quality of fettling material is very great where the iron to be puddled is largely charged with phosphorus. Some of the Cleveland ironmasters puddling highly phosphuretted pig, import large quantities of a very pure ore from Norway and Sweden, and these, used as fettling, not only add a large quantity of iron to the charge, but they take up a large proportion of phosphorus or phosphoric acid in the slag; and the puddled bar, which would otherwise be very cold short, is found to be fine grained, ductile, and fitted for nearly all the purposes of good makes of bar iron.

STEEL RAILS AND TYRES.—Messrs. William Bird & Co. in their monthly circular speak as follows of the relative use of steel for tyres and rails in England and on the Continent. They say: "Compared with foreign railway specifications for 5,000, 6,000 and 8,000 tons of rails, and 5,000 to 8,000 and 10,000 Bessemer steel wagon tyres on a line, our home requirements of a few tons at a time (Bessemer steel rails in the proportion of 200 tons to 5,000 tons of wrought iron are just now advertised by the Great Northern) appear quite insignificant, and in the course of the past year there have been contracts of 40,000 tons given out to French works for both Bessemer and Martin rails, and 5,000 tons of French make have even found their way to the United States lines."

Machine Puddling.—In this direction nothing appears to have been done since the unsuccessful attempts made at Dowlais, and those, still earlier, by Mr. Tooth and Mr. Yates. Nor do we learn that the revival of a former attempt to introduce air directly within the iron in the puddling furnace, by means of a tubular rabble with a flexible air pipe, has made any progress. This mode of introducing air was heard of some little time ago, as "the Richardson process." So, too, there was "a Radcliff process" of knocking four or five puddled balls into one, and rolling or forging them direct into a single large bar. There were obvious objections to this mode of working, that especially of the risk of unsound welds, and the saving of a single heat is not enough to compensate for this risk, so fatal to the product.—*Engineering.*

Tempering Taps.—A correspondent of the "Scientific American" writes as follows: Most of your readers are aware of the difficulty in tempering taps and reamers without springing, especially long and large ones. To accomplish this let the blacksmith select his steel for the job and forge the tap with a little more than the usual allowance, being careful not to heat too hot, nor to hammer too cold. After the tap or reamer is forged, heat it and hold it on one end upon the anvil. If a large one, hit it with the sledge; if a small one, the hammer will do. During this operation the tap will give way on its weakest side and become bent. Do not attempt to straighten it. On finishing and hardening the tap will become perfectly straight. If any are doubtful, a simple trial will convince them.

Atlas Works, Bessemer Plant, Glasgow.—These works are fully illustrated in "Engineering," Jan. 1. A pair of three-ton vessels are arranged in the ordinary English style. There are two air furnaces and two cupolas, capable of holding the whole charge; also two spiegel furnaces. The charges are elevated by hydraulic hoists. There are two independent pairs of blowing cylinders, with twenty-inch steam and 2 6-inch air cylinders of two and one half ft. stroke, making seventy revolutions. The converters have cast-iron trunnion hoops. There is nothing new in the design. The American works have greater facilities, and can produce a larger product with the same number of vessels.

The Richardson Process of Puddling.—This is reported to be gradually maturing in England, and several improvements are announced. The blowing out of the silicon sparks through the stopper-hole has now been overcome by the employment of a hooded rabble. It is said that at the Parkhead Works, near Glasgow, where the process has been in operation nearly a year, not a bad bar has been produced. At Messrs. Palmer's Works, Jarrow, the use of the tubular rabble has been supplanted, Mr. Ridley having introduced a method of injecting the blast through the pipes introduced through openings at the side of the furnace, and excellent results are said to be produced by this method.

Fire-brick in Steel Making.—An exchange states that many works are erecting in this county for the manufacture of steel rails, and that one of the steel furnaces will use a million fire-bricks a year! This can hardly refer to the Bessemer Works, where no fire-brick are used, except to line the nose of the converter, and for the spiegel furnace, which will last a couple of years. The Siemens furnaces are probably as durable as ordinary reverberatory furnaces, and we can hardly imagine a steel process in which brick alone will cost say ten dollars per ton of product.

Steel Railway Carriages.—The recent report of the Oude and Rohilkund Railway Company, states that the steel rolling stock, which had been the cause of some anxiety to the board, was very likely to turn out a complete success. They had, at present, two long metal carriages, capable of accommodating 200 passengers each, and were found to be very suitable for the traffic. The remainder of the steel rolling stock, for which a supply of wheels and axles had been forwarded, was now being made available.

Improved Rolling Mill Machinery.—Messrs. Thomas Perry & Son, of the Highfields Works, Bilston, have made a train of 24in. rolls, three high, for rolling steel rails. They have also just completed a universal mill for rolling long narrow plates without shearing. This kind of rolling is effected by the addition of vertical rolls behind those which are horizontal, and it is a plan which has been for some time most successfully worked on the Continent. (See article on universal mill, in another column.)

Washing Coal.—Since the expiration of the patent for the French coal-washing machine, so long held by Mr. Morrison, of Ferry-hill, it is coming into extensive use, and with the best results. Worthless "slack" is now powdered, its pyrites separated, and it is afterwards coked into excellent fuel at an almost insignificant cost. In France and Belgium great attention is paid to washing refuse coal, and the adoption of the French mode would save vast sums of money here.

Troy Bessemer Steel Works.—The steel works of Messrs. John A. Griswold & Co., burned in October, are being rebuilt by Mr. A. L. Holley, late superintendent of the Pennsylvania Steel Works. The two-ton converter has been at work all winter, producing some ten tons of ingots daily. The five ton plant will be considerably enlarged, and will be running in July. A new blowing engine, the largest Bessemer engine in this country, is building by Messrs. Paulding, Kemble & Co., Cold Spring.

Remarkable Production of a Charcoal Furnace.—From January 1st to 31st inclusive, the Irondale furnace of E. Harrison & Co., produced 784 tons of pig-iron of 2,268 lbs. to the ton. The daily average was therefore $25\frac{1}{3}$ tons. This is a charcoal furnace measuring $9\frac{1}{2}$ feet in the bosh, and 40 feet in height, and uses nine-tenths Iron Mountain ore.—*Bulletin of the Am. Iron and Steel Association.*

The Specific Gravity of Steel oscillates between 7.2 and 7.9. The hardening of the metal by tempering is accompanied, as Réaumur long ago observed, by a notable diminution of specific gravity; and M. Caron has noted that the specific gravity of steel diminishes with the number of times it is tempered.

New Furnace of the Sterling Iron and Railway Company.—A new blast furnace building for this company, after the designs of Mr. Rumpff, of the West Point Foundry, is 60 feet high, with 12 feet boshes.

Large Rolls.—A pair of rolls for Sir John Brown's Works, Sheffield, recently cast at the Phœnix Works, Bilston, were of the following dimensions:—Length of roll $15\frac{1}{4}$ feet, diameter 3 feet; weight, 18 tons.

Highest Blast Furnace in the United States.—The Port Henry furnace, 70 feet high, with 16 feet bosh, is stated to be the highest American furnace.

RAILWAY NOTES.

RATE OF PROGRESS OF THE MOUNT CENIS TUNNEL.—During the past year an advancement of 1,320.15 meters has been made at the Mount Cenis tunnel, of which 638.60 was driven on the Italian side, and 681.55 meters on the French. The advancement has been 110 meters per month, or 53.20 on the Italian side, and 56.80 on the French; and at this rate of progress the time necessary for the completion of the tunnel would be twenty-eight months, or about April, 1871, and for opening the railway about six months more, or in less than three years.

The following table, from "Engineering," shows the yearly progress that has been made with these works since their commencement in 1857:

Year.	Bardonnêche.	Modane.	Total Advancement. Each Year.	Total Advancement. At end of Year.	Expenditure.
	meters.	meters.	meters.	meters.	francs.
1857. 1858.	284.85	212.75	497.60	497.60	3,369,000
1859.	236.35	132.75	369.10	866.70	1,630,000
1860.	203.80	139.50	343.30	1,210.00	3,000,000
1861.	170.00	193.00	363.00	1,573.00	2,500,000
1862.	380.00	243.00	623.00	2,196.00	2,000,000
1863.	426.00	376.00	802.00	2,998.00	3,500,000
1864.	621.20	466.65	1,087.85	4,085 85	6,552,000
1865.	765.30	458.40	1,223.70	5,309.55	5,502,000
1866.	812.70	212.29	1,024.99	6,334.54	5,644,000
1867.	824.30	687.81	1,512.11	7,846.65	6,000,000
1868.	638.60	681.55	1,320.15	9,166.80	7,500,000
	5,363.10	3,803.70	9,166.80	....	47,197,000

ENGINES, WORKING AND EXPENSES ON THE SEMMERING RAILWAY.—At a recent meeting of the *Société des Ingénieurs Civils*, M. Gottschalk, locomotive engineer of the South Austrian Railway system, stated that the successive improvements in traction on these lines, and especially on the Semmering section, up to the end of 1865, had not only been maintained, but had still continued to progress in 1867. Passing over the results of 1866, which were abnormal in consequence of the war, the expenditure on the entire system, Semmering included, had been 0.977f. per train kilometer, as against 0.992f. for 1865. For Semmering alone the cost of traction in 1865 had been, for those trains that could be taken up entire, 1.70f. per train kilometer, and for goods trains divided and taken up at two trips, 3.40f. In 1867 these figures were reduced to 1.666f. for the single train, and 3.33f. for the double train. These reductions would have been greater but for the work to replace in proper condition the overworked rolling stock of the year of the war, and the unusual quantity of snow during December. It may then be affirmed that the already so greatly reduced expenses of traction on the Semmering and other lines are not, as some persons think, the consequences of its recent construction. Locomotives in use last above eighteen years; their repairs are placed to the current account, as well those of vehicles of all kinds. Damage to rolling stock, often considerablo, caused by foreign service, is always borne by the traction service. The radius of 189 meters in the Semmering curves prevents the use of two locomotives to the train without danger, but this obstaclo does not exist on the Brenner line, and the company has been authorized to run its trains of 350 tons across in one journey by means of two locomotives, one in front and the other in rear of the train. Besides complete security in case of any breakage in the coupling, this plan offers obvious advantages, which it is unnecessary to specify. One great difficulty in working the Brenner line is the means of regulating the speed in the descent. The proportion of brakes sufficient on the Semmering with curves of 189 meters is not so on the Brenner with curves of 300 meters, although the inclines are the same on both lines. The Semmering line is double, the Brenner single; the consequence is a marked difference in adhesion. These difficulties are to some extent overcome by the use of sand, but though it is largely employed it is insufficient. The descent was therefore an occasion for the use of reverse steam, for which purpose all the Brenner locomotives have been provided with the Le Chatelier apparatus, similar to that adapted to the Mediterranean locomotives.

The new goods engines, on the same general principles as the modified ones of the Semmering, with the entire mechanism and exterior appurtenances, give the best results. The maximum weight of the goods trains last winter reached 369 tons. Here the gross weight of each train became

Weight of wagons	369 tons.	
" 2 locomotives—94,600 kilos..	131	"
" 2 tenders—36,400 kilos......		
	500	

Multiplying this weight by 6 + 25 kilos. we find that the tractive power developed is 155,000 kilos., and that the work of these two engines at a speed of 15 kilos. por hour is about 850-horse power, or 425-horse power per engine. Under these circumstances vaporization is not forced, as each square meter of heating surface only equals two and a half horses.

RAILWAY PROGRESS IN RUSSIA.—The first railway in the empire was opened in 1838, and for seven years it was the only one. One or two short lines were opened in the course of the next two years, but, in 1848, a line was opened from Warsaw to the Austrian frontier. It was not until after the death of the Emperor Nicholas that railway enterprise made any very great strides in Russia. Since then, however, the process has gone on upon an accelerating scale. There are at present 5,960 versts of line open, 3,337 versts are in courso of construction, and a Council of Ministers has decreed concession for eight new lines, declared to be indispensable, the gross length of which is 3,235 versts. Tho majority of tho lines opened have been constructed with foreign capital, and the funds for the new undertakings are sought for from the same source, and there is now a full stream of English capital directed from home projects flowing into Russia to enrich that country, and to increase the strategic power of the Czar.

The following are the lines in course of construction: Kiev-Balta (all that remains to be completed of the Moscow-Odessa line), 428 versts; Odnoga-Berdcyzeff, 27 versts; Odnoga-Woloczysk (Polesia-Bukowina), 167 versts; Tiraspol-Kischeneff (Bessarabia), 65 versts; Kursk-Charkoff-Taganrog-Rostoff (Moscow and Taganrog line), 763 versts; Jeletz-Orel (continuation of Grias-Jeletz), 173 versts; Orel-Witepesk (last portion of the line connecting the St. Petersburg-Warsaw and St. Petersburg-Moscow-Odessa lines, open to Rostavl, four-fifths of the distance), 493 versts; Grias-Boryssogleb (extension of the South-Eastern in the direction of the Volga), 192 versts; Kaslov-Tambov (extension of the South-Eastern in the direction of the Volga), 74 versts; Odnoga-Schuya, 84 versts; Troizka-Yaroslav, 196 versts; Poti-Tiflis, 284 vorsts; Moscow-Smolensk (direct connection between Moscow and the Riga-

Dünaberg-Orel line), 391 versts. Total, 3,337. Of the Russian lines fifteen have a government guarantee, and their capital amounts to 237,856,000 roubles.

Few of the Russian railways have, as yet, managed to become self-supporting, and Englishmen are warned by newspaper correspondents to keep clear of the railway mania, now at its height. The government is understood to have suffered some heavy losses on account of its guarantees, but it can afford to stand many more, if necessary to the development of the country.

Differing from the standard adopted in most European countries, the Russian gauge is five feet, an arrangement intended to prevent foreign railway carriages from entering the country in peace, and still more in war. Only in Poland the ordinary German guage of four feet eight inches has been adhered to. A weak side of the Russian railways is the insufficiency of their rolling stock, which, being almost entirely imported from abroad, is a dear commodity, and, in consequence, kept at a low figuro. Accidents are not very common, Russian engine-drivers, who are apt to indulge their liquorous propensities, being discarded on many lines in favor of steady Germans. Yet, as the number of passengers is small, the death-rate by accident is necessarily great. *From Correspondence of the London Times.*

Effect of Northern, East and West Lines upon New York City.—This subject is discussed at length in "Harpers' Magazine;" the conclusions are as follows: Upon the completion of the Hoosac tunnel, Boston will have two lines direct to the lakes. The line by way of Springfield encounters an elevation of 1,450 feet above tide, and, in its ascent towards the west, has a grade of 83 feet to the mile. The line by way of the tunnel rises at the summit to 1,106 feet, and passes through the tunnel at an elevation of 838 feet above tide; but it has no grades steeper than 58 feet.

New York enjoys the benefit of tide-water from Troy to the ocean, and of a railway whose steepest grades (at Poughkeepsie) are only fifteen feet. The Harlem road is less favorably situated for carrying through freights, as it is obliged to pass over the same mountain range through which the Hudson River makes a clean sweep. Except for about 104 days in each year, when the river is closed with ice, New York has the immense advantage of the Hudson river, capable of floating the largest barges at rates for freight with which railroad lines cannot compete, and at all times it has two lines of railway. In extending her enterprises to Lake Ontario, it will be impossible for Massachusetts to secure the advantage which the New York Central enjoys in passing through the Allegany at the dip at Little Falls. The road and canal there are about 300 feet lower than Lake Erie, and but about 100 higher than Lake Ontario, whereas the line suggested for competition must pass over the mountain at unfavorable grades.

New York has the inestimable advantage of a canal and line of railroad which *descend* from Lake Erie to tide-water, with the exception of a trifling counter-elevation, and has only 110 feet to overcome between tide-water and Canada. If New York had no road but the Erie it would be on a footing with the Atlantic sea-ports south, as its grades are about on a par with those encountered by them. Pennsylvania, Maryland and Virginia are obliged to surmount elevations in the neighborhood of about 1,500 feet. North and South Carolina have high and nearly impassable mountains behind them; but South Carolina avoids hers by using the roads of Georgia, which are constructed around them and through an opening at Chattanooga in another range. The history of the Erie railroad will be relied upon by many to prove that it was a great error in policy not to confine ourselves to *the route indicated by nature* for our canal and great lines of railway. Washington was the first to point it out when in command of the revolutionary forces located in the valley of the Mohawk, and the first to express the hope that it would be improved. His education as an engineer enabled him at a glance to perceive that New York stood unrivaled in her facilities for intercourse by land and sea, and consequently for commercial supremacy.

Italian Railways and Works.—The public attention is so much directed to tho Mont Cenis tunnel that the works upon subordinate portions of the great line connecting the northern and southern sides of the Alps are little noticed. Upon the Italian side of the mountains there is much difficult engineering. The line from Bardonnèche and Bussoleno, 25 miles long, has a tunnel three-fourths of a mile long, and several fine bridges at Meana, a succession of lesser bridges on the whole line, and no less than 24 tunnels in all. A line 40 miles long from Gloia and Tarente has many features of great difficulty, requiring "trial sections" and careful preliminary reconnoissances before any attempt could be made to delineate the approximate route. An iron bridge over the torrent San Stephano, has a central span of 180 feet, and is 200 feet above the water. A viaduct over the Castellanela is 240 feet high from the river. This is an iron structure on lattice-work iron piers. The character of the structures on these lines is highly spoken of by experts.

The Italian railways in operation at the close of last year was as follows:

		Kilom.
Alta Italia Railway Company:		
	Piedmontese lines	1,030
	Lombard lines	477
	Central Italian lines	294
	Venetian lines	437
	Total	2,238
Roman Railway Company:		
South section	Naples and Leri, Cancello and St. Severino Railway	181
South section	Ancona and Orte Railway	238
North section	Leghorn, Azetina and Ligurian lines	761
North section	Empoli, Siena and Orvieto Railway	216
	Total	1,396
Southern Railway Company:		
	Mediterranian network	183
	Adriatic network	984
	Voghera, Pavia and Brescia Railway Company	149
	Total	1,316
Victor Emmanuel Railway Company:		
	Palermo and Termini Railway	37
	Messina and Catania Railway	95
	Reggio and Lazzaro Railway	17
	Total	149
Total of four groups		5,099
Turin and Cirie Railway		8
Fell Railway over Mont Cenis from Susa to Frontier		27
	Total	5,134

A New Engineering Feat is talked of at Chicago. It is proposed to cut off the river several miles above the city, and conduct its entire volume of water to the lake by a canal, and convert the channel into a system of railroads, where all the lines converging in the city might meet in one grand central station.

THE CORNWALL BRIDGE.—The bill passed in the State Assembly for the construction of a suspension bridge across the Hudson river, 42 miles above New York city, appears likely to be acted upon, and the designs and calcu ations for the structure are now almost completed. The total length of the bridge, including approaches, will be 2,499 feet, the length between towers, 1,665 feet; the clear span, 1,600 feet; the height of the towers, 280 feet; distance from platform to water level, 150 feet. One of the towers will be in 30 feet of water, the other will be a land pier. The bridge will be carried by twenty cables disposed in four systems; each cable will be fourteen inches in diameter, formed of steel strands, disposed as in Mr. Roebling's bridge at Cincinnati. (It is now proposed to make the cable of steel bars.—Ed. V. N. Eng. Mag.) Thero will be 58,084 cubic yards of masonry in the tower.

There will be a road platform as well as a railroad track, which latter is calculated to a working load of 2,400 tons. The platform of the bridge would be filled by 32 passenger cars, or 53 locomotives, and 18,000 people, whilst the working strength allows for the crowding of 34,560 people and 60 locomotives upon the platforms at one time.

The bridge, which is estimated to cost about £500,000, will connect the mining districts of Pennsylvania with the New England States, and effect a saving of four shillings a ton on the 4,000,000 of tons of coal now consumed annually in New England. At present about 1,000,000 tons are carried every year down the Hudson to the depots along the coast. By means of a short branch made to the bridge, the Erie railway will be enabled to obtain a station in New York, and be saved the expense and inconvenience of transferring passengers and goods by ferry to their terminal station in Jersey City.

Pending the completion of the bridge, a ferry will be established at the point of crossing, for transfer of the traffic, as the railway will be completed up to the east and west banks of the Hudson long before the permanent connection can be made.—*Engineering.*

WOODEN MINING RAILWAYS.—The wooden railroad now completed between Clifton and the Adirondack mines in New York, is described as folows: The rails are of hard maple scantling, 4 x 6 inches, set on edge in slots in round ties, and keyed in the slots by two wooden wedges driven against each other, project two inches above the ties. The rails admit the bending sufficiently to make the curves.—The ties are laid on the earth and ballasted in the usual manner to two inches of the bottom of the rail. It takes 21,120 feet, board measure, of scantling for a mile, and 1,760 ties at three feet apart. The road is a very rough one, with a great deal of trestle work, some of it over 30 feet high, which is vastly more expensive than a level route. The engines used weigh from ten to fourteen tons. The rails will probably last about five or six years. An engine will move about 30 tons of freight at about six to eight miles an hour, with heavy grades and sharp curves. The company expects to move over the road next year from 50,000 to 1,000,000 tons freight. Trains have passed over the road, light, at tho rate of twenty miles an hour; but this would not do for freight.

The proposition to build a wooden track railway along the Lake Superior copper range from Portage Lake to the Cliff mine has met with great public favor. The cost, except the first five miles to gain the summit of the range, has been estimated (wooden track) at $4,000 per mile; the bidding price for timber prepared and delivered being $2,300 per mile, leaving $1,700 per mile for construction account. This is considered more than sufficient, as all agree the labor will be no greater than that of making a common wagon road or earth-covered corduroy, which is done generally for about $4 or $5 per rod, or $1,250 to $1,600 per mile.

THE FIRST EFFECTIVE LOCOMOTIVE IN AMERICA.—The first effective locomotive engine in America—the "Old Ironsides"—says Mr. E. Haskill, in the "Coachmakers' Journal," was buil in Philadelphia, from a draft by Rufus Tyler, a brother-in-law and partner of the late Matthias Baldwin. In consequence of a misunderstanding the copartnership was dissolved, and Mr. Baldwin completed the engino in 1832. The wheels were made of wood, with broad rims and thick tires, the flange being bolted on the side. The engine was first put in motion on the Germantown and Norristown railroad. She ran a mile an hour, and was considered the wonder of the day. On trial it was ascertained that the wheels were too light to draw tho tender, and to overcome this difficulty the tender was placed in front of the engine, which kept the wheels on the track. Mr. Baldwin and his assistants pushed the engine ahead until it attained some speed, when they all jumped on, their weight keeping the wheels from slipping. The boiler being too small for tho engine, steam was only generated fast enough to keep the engine in motion a short time, so that they were compelled to alternately push and ride until they arrived at the Germantown depot. The return trip to Philadelpnia was performed by alternately riding and pushing in the same manner.

Several successive trials were had during the year following; after each, Mr. Baldwin added improvements and made alterations in its mechanism. That same engino is still in existence in Vermont.

RAILROAD MATTERS IN CALIFORNIA.—The open winter has been favorable to railroad enterprises on the Pacific slope. The Central Pacific has been enabled to push forward supplies, and to continue grading and track-laying without interruption. The new mineral discoveries in Nevada will much increase the traffic on this road through California and Nevada; indeed, the way business generally on both ends of the Pacific railroad has exceeded all expections for so early a period.

There are some signs of activity on the Western Pacific railroad, from Sacramento to Oakland. Meanwhile the California Pacific, via Vallejo, has reached Sacramento, and the passenger traffic is steadily increasing. The connection with the Nepa Valley railroad is progressing. The extension to Marysville is expected to be completed by the middle of summer. Marysville will soon have railway connection with Sacramento on the east side of the Valley, through the Central and Yuba lines.

The Southern Pacific railroad is graded from San Jose to Gilroy, and some 30 miles of track nearly completed.

BALTIMORE UNION RAILROAD.—This enterprise was started some time since, with a view of giving an outlet at tide-water to the various railroads, built and contemplated, entering the city on its north side. It is likely to be fully completed during the ensuing two years. The contractors are, it is said, pushing it forward as rapidly as prudence will allow, and the road will have a tunnel just out of the city some 2,900 feet long. Three shafts have been sunk, but the difficulty of water is so great that the question of making an open cutting to be afterwards arched and filled in is being discussed.

SPANISH RAILWAYS.—The entire railway system in Spain is, in length, about 3,125 English miles, and about £60,450,000 have been expended, without in the aggregato ever having a farthing for distribution as profit. The railways were built extravagantly, they are ill fed for want of good carriage roads in the country, and altogether they are perhaps the most abject failures ever witnessed.—*Bulleonis.*

Stockholm Junction Railway—Engineering Difficulties.—The railway termini of this city have heretofore been at its extreme opposite ends. The new junction line commences at the southern end by entering a tunnel bored through solid granite, and describing a slight curve on plan. This tunnel is 1,500 feet long and 32 feet wide by a height of 19 feet, and passes under a very populous part of the city. Then follows a cutting 2,400 feet long, the retaining walls on either side being 30 feet high, executed in solid masonry. Next comes a bridge across the Söder, after which the line traverses the 'Stad' quarter, then crosses the Riddaneholm canal, and lastly joins the Northern railway over a high embankment. Considering the short distance, perhaps no line in the world has presented greater difficulties to the engineer, and it is only in Sweden that this could have been effected at so low a cost, namely, about £61,000. The granite in the tunnel was blasted by means of nitro-glycerine, 30,000 pounds being used in the operation.

French Railways.—The entire extent of railway in operation in France, Stptember 30, 1868, was 9,934 miles as compared with 9,671 miles September 30, 1867, showing an increase of 263 miles.—The entire amount earned on all the French railways to September 30 this year, was £19,684,405, as compared with £19,424,998 in the corresponding nine months of 1867, showing an increase of £259,407 this year. This increase was entirely attributable to the new network and the miscellaneous lines, the old network presenting a decrease in the first nine months of this year of £188,156. The general result of the working of the French lines of the first three-quarters of this year was a decrease of 4.78 per cent per mile worked, as compared with the corresponding period of 1867; but a somewhat better result may be anticipated for the last quarter of the year. Nevertheless, French railway traffic has shown less elasticity in 1868 than in several preceding years.—*Herapath's Railway Journal.*

The Gauge Question.—The narrow gauge is now replacing the broad gauge system on several of the branches of the Great Western railway. This change will doubtless lead to some legal difficulties, certain coal merchants having built a number of broad gauge trucks, and made contracts with the company for the conveyance of coals therein for a period of several years. It is understood that orders have been received at the workshops of the Delaware, Lackawanna and Western railroad, in Scranton, to rebuild no more locomotives for the wide gauge.—This looks to the not distant laying of the third rail, which is also necessitated by the leasing of the Morris and Essex railroad.

British Railway Mileage Receipts and Expenses.—The earnings of British railways per mile worked have shown a steady tendency to increase upon the whole. In 1849 the total receipts per mile were £1,957; in 1850, £1,994; in 1851, £2,176; in 1852, £2,141; in 1853, £2,345; in 1854, £2,510; in 1855, £2,580; in 1856, 2,660; in 1857, £2,559; in 1858, £2,510; in 1859, £2,574; in 1860, £2,661; in 1861, 2,629; in 1862, £2,522; in 1863, £2,528; in 1864, £2,667; in 1865, £2,700; in 1866, £2,755; in 1867, £2,770. But while the working expenses of British railways were 46.83 per cent of the traffic receipts in 1849, they had increased to 54.57 per cent of the receipts in 1867.

Traffic of the Metropolitan Railway.—It is officially stated that during the six days of the Christmas holidays, from the 24th to the 30th, 800,072 passengers passed along the lines of this company.

A Railway Library of 1,000 volumes has been established by the Boston and Albany railroad. An apartment in the passenger station at Boston has been fitted up for it. The library is divided into two departments, the Consulting and the Circulating.—The first comprises railway enactments, English and American; encyclopedias. The circulating department embraces standard works of interest, instruction, fiction, and bound volumes of the most valuable periodicals of past years, 500 or 600 in number. Any person in the service of the company on the line between Boston and Albany is privileged to take books from this department, two at a time, and to hold them two weeks, the train baggage-masters and station agents along the route transmitting them on Tuesday and Thursday of each week.

The Twelve Great Railway Companies of Great Britain are: The Caledonian; Great Eastern; Great Northern; Great Western; Lancashire and Yorkshire; London and Northwestern; London and Southwestern; London, Brighton and South Coast; Manchester, Sheffield and Lincolnshire; Midland; Northeastern, and Southeastern. The twelve lines own 6,595 locomotives, valued at over eighty millions of dollars.

Warming Street Cars.—The cars of the Albany and West Troy railroad (seven mile route) are warmed by stoves. The stove occupies the place of one passenger (or what would be appropriated to say three passengers in New York city); it rests on the bottom of the car and passes through the seat. The adjacent passengers are protected by high screens.

Large Locomotives.—The 4-cylinder goods engines on the Northern railway of France weigh 59 tons, and have $17\frac{1}{3}$ in. cylinders, $17\frac{1}{3}$ in. stroke, and 12 coupled wheels 3 ft. 6 in. in diameter. The "Pennsylvania," on the Reading railway, has 2 cylinders 20 in. in diameter, 26 in. stroke, and 12 driving wheels 3 ft. 11 in. in diameter. Some of the Great Northern (England) engines weigh 56 tons.

New Line from Europe to India.—The railway just commenced from Constantinople to Adrianople, will ultimately join the Austrian lines at Belgrade, and complete the European part of the Euphrates Valley line to India. This accomplished, its prolongation either along the Euphrates Valley or that of the Tigris can be but a question of time and policy.

Another Trans-Continental Railway.—It is stated that the Czar of Russia has sent two engineers to inspect the Pacific railroad, with a view to utilizing whatever information they may obtain in the construction of a road from St. Petersburg to Chinese Tartary.

The Railway Mania.—A period of remarkable activity in railway construction is just commencing. Cannot promoters and managers be persuaded to avoid the grand mistake of former times—*bad work,* costly to maintain, unsafe, and ruinous in the end.

Locomotive Cars.—"The Engineer" states that arrangements are being made for working a section of one of the largest railway systems in England on the steam carriage principle.

The Bridge at Columbia.—The Pennsylvania railroad bridge spanning the Susquehanna at Columbia was opened to general travel on January 4.

NEW BOOKS.

A Handy Book for the Calculation of Strains in Girders and Similar Structures and Their Strength, consisting of formulæ and corresponding diagrams, with numerous details for practical applications, &c. By William Humber, Assoc. Inst. C. E. Author of a practical treatise on cast and wrought iron bridge construction, a Record of the Progress of Modern Engineering, &c. 12mo. with three plates and nearly 100 wood cuts.

Mr. Van Nostrand is photographing the plates and text of this work and will issue it in a few days.

The "Builder" speaks of the work as follows: This volume is not intended to supersede larger and more elaborate treatises. It is intended to take a place midway between these and the "Engineer's Pocket-book" class. The former are too elaborate for convenient use, the latter have not space enough for the introduction of many useful formulæ. The "Handy Book" represents the mean between the two extremes, and will be found a valuable companion by the practical man. The author not only gives the most applicable formulæ for particular cases, but he illustrates them by means of excellent diagrams, and thus makes his subject easily intelligible to any one whose mathematical knowledge extends to equations. The method of drawing a parabola—the base and height being stated—which Mr. Humber gives, is a happy one. The book indeed recommends itself better than any notice we could write.

The Indicator Diagram Practically Considered. By N. P. Burgh, Engineer. London: E. & F. N. Spon, 1869.

This is a 12 mo. of 160 pages, containing numerous wood-cuts. The object aimed at is best stated in the words of the preface. "The means I adopted" to professionally test some indicator diagrams "were to consider, first, the proportions of the details that regulated the admission, expansion and exhaustion, of steam; and, secondly, their geometrical delineation. Having proceeded thus far, I then concluded that, as the length of the motion for the indicator barrel was virtually that of the stroke of the piston, the scale of the geometrical test that I employed must be subject to that circumstance. I accordingly made a drawing of the cylinder ports, slide valve, link motion, eccentrics and rods, a portion of the length of the piston, length of the connection rod and crank circle at the same scale that the stroke of the piston, in inches, was equal to the length of the indicator diagram. I acquired thus a correct knowledge of the positions of all the details that regulated the steam at the points of admission, cut-off, expansion, exhaustion, compression and lead, in relation to the positions of the piston and crank pin at the same scale as at the diagram; and by laying it on the crank pin's circle, I saw at once *how it was formed in relation to time and speed*, and the *cause of the defects*, if any existed—indeed being the only method of gaining that information *truthfully*, which is illustrated by the plate in the frontispiece."

The work also treats of the indicator and diagrams in all their points and relations.

Long and Short Span Railway and Highway Bridges. By J. A. Roebling, C. E.

Mr. Van Nostrand is producing this work in superb style. It is a large folio, eighteen by twelve inches, with folding plates; some of them 60 inches long, engraved on copper. It will be ready in April.

Mr. Roebling's name, alone, will insure a large sale for this work. The results of his labors and studies, all these many years of devotion to the subjects of iron, steel and bridges, will be eagerly sought for by the profession all over the world.

The One Great Force. The Cause of Gravitation, Planetary Motion, Heat, Light, Electricity, Magnetism, Chemical Affinity, and other Natural Phenomena. By Crisfield Johnson. Buffalo: Reed & Lent.

The author of this little work first calls attention to the steadily increasing belief among the leaders of the scientific world that heat, light, electricity, magnetism, and chemical affinity are all manifestations of the same force and convertible into each other, and, after reference to Faraday's essay on the "Conservation of Force," and to Grove's doctrine of the correlation of forces, lays down the proposition that "The one great force of the material universe is the self-repulsion of caloric acting on the inertia of ordinary matter." This force, he asserts, is the source or cause of attraction, heat, light, gravitation, capillary attraction, planetary motion, electricity, magnetism, cohesion, adhesion, chemical affinity, combustion, explosion, tides, the building power of animals and plants, and the circulation of the blood. If he does not prove the truth of his proposition, he at least shows the probability of its correctness. We recommend the book to the study of all who take an interest in the subject of the origin of natural forces. *American Artisan.*

Engineering. An Illustrated Weekly Journal. Conducted by Zelah Colburn. London: 1869.

The seventh volume of this most excellent journal is fully up to the previous volumes in extent and quality of matter. We do not see how any engineer who is familiar with Mr. Colburn's writing—his extensive, positive and practical knowledge, and his clear, concise, searching and comprehensive treatment—can do without this journal. In the pretty careful reading of 50 to 70 scientific magazines and newspapers every month, we find much that is thoroughly good and well put, and a great deal that is inconclusive, if not trivial. But we rarely find anything in Mr. Colburn's writings that is not founded upon large views and extensive reading and experience. Even when somewhat hasty and incomplete, as newspaper articles must be, in comparison with exhaustive treatises, Mr. Colburn's articles are full of ideas, apt illustrations and strong points.

A Manual of Elementary Chemistry, Theoretical and Practical. By Geo. Fownes, F. R. S., late Professor of Chemistry in University College, London. Tenth edition, revised and correeted. London: John Churchill & Sons, New Burlington street, 1868.

There is probably not a student of chemistry in this country to whom the admirable manual of the late Professor Fownes is unknown. It has achieved a success which we believe is entirely without a parallel among the scientific text-books in our language. This success has arisen from the fact that there is no English work on chemistry which combines so many excellences. Of convenient size, of attractive form, clear and concise in diction, well illustrated, and of moderate price, it would seem that every requisite for a student's handbook has been attained.—*Chemical News.*

A Synopsis of the Patent Laws of Various Countries. By Alex. Tolhausen, Ph. D., Translator at the Patent-office, London: Trubner & Co.

This work contains, in a condensed form, all the necessary information respecting fees, documents required, disclaimers, prolongation, infringements, jurisdiction, and legal proceedings, &c., &c., together with references to the acts and ordinances themselves. An eager inventor can now ascertain, in a few minutes, the entire cost of patenting his invention in every quarter of the globe.

TRAITÉ ÉLÉMENTAIRE DE PHYSIQUE, PAR A. PRIVAT DESCHANEL, Professor au Lycée Louis le Grand. Paris: 1868.

This work would have been called a "Natural Philosophy" in our school days, but it is rather in advance of the "Comstock's Philosophy" we studied, in style and treatment. It appears to be even an improvement on Ganot, which is saying a great deal. We hope it will be translated, and, above all, that the wood-cuts will be reproduced in something like the French style of high art. The pre-corlissite treatment of the steam engine, for instance, in most of our modern text books, and the pre-raphaelite wood-cuts that disfigure them, are unworthy of the aspirations of American youth, and the pretensions of American publishers.

ELEMENTARY GEOMETRY. By J. M. WILSON, M. A., Fellow of St. John's College, Cambridge, and Mathematical Master at Rugby School. Macmillan & Co.

This is an attempt considered very promising by reviewers, to render an exceedingly dry subject attractive, and hence familiar and useful. The arrangement and treatment of the facts are changed, and practical applications of geometry are introduced. Several attempts had previously been made in England to make Euclid more practical, but they have not been very successful there. In France, on the contrary, Legendre and La Croix each composed elements which have completely supplanted Euclid. It is their models that Wilson has greatly followed.

ART OF CONSTRUCTING AND REPAIRING COMMON ROADS. Weale's Rudimentary Series. London: Virtue & Co., 1868.

A fourth edition of this volume of Weale's Rudimentary Series, with additions, has been published. It includes a "Survey of the Metropolitan Roads," by S. Hughes (which might be left out without much loss); the "Art of Coustructing Common Roads," by Henry Law; "Remarks on the Maintainance of Macadamized Roads," by Sir John Burgoyne; and a note by Mr. Robert Mallet on the causes of the apparent failure of macadamized roads in certain localities. Mr. Mallett regards asphaltic macadamizing as the very best material for the street surfaces of populous cities. A large amount of valuable instruction is given.

MOLECULAR AND MICROSCOPIC SCIENCE.—By MARY SOMERVILLE, in two volumes. London: John Murray. 1869.

The scope of the work is thus stated in the preface: "Microscopic investigation, organic and inorganic, is so peculiarly characteristic of the actual state of science, that the author has ventured to give a sketch of some of the most prominent discoveries in the life and structure of the lower vegetable and marine animals, in addition to a few of those regarding inert matter." The work is quite fully illustrated.

THE MONTHLY MICROSCOPICAL JOURNAL.—TRANSACTIONS OF THE ROYAL MICROSCOPICAL SOCIETY, AND RECORD OF HISTOLOGICAL RESEARCH AT HOME A D ABROAD. Edited by HENRY LAWSON, M. D., F. R. M. S., London. No. 1, Jan. 1869. This is a new illustrated Journal of this important and growing science.

TABLES SHOWING THE LENGTH, IN FEET, OF A DEGREE, MINUTE, AND SECOND OF LATITUDE AND LONGITUDE, WITH THE CORRESPONDING NUMBER OF STATUTE MILES IN EACH DEGREE OF LATITUDE, &c., &c. By R. C. CARRINGTON, F. R. G. S., of the Hydrographic Department of the Admiralty.

QUANTITIES MADE EASY; A QUICK AND ACCURATE METHOD OF TAKING OUT QUANTITIES IN BUILDINGS. By H. A. CREASEY. F. SHAW, Dockhead.

These pages consist of lists of tho items in an ordinary dwelling house, so that an estimator may not forget or overlook any in taking out his quantities. Instead, however, of keeping all the trades separate, the writer puts each room separately, so that the same headings would have to be written over and over again, and the resulting sum would be very much higher than the same estimator would bring to it if he pursued the more customary, expeditious and common-sense mode.

A TEXT-BOOK OF NATURAL PHILOSOPHY. An accurate Modern and Systematic Explanation of the Elementary Principles of the Science. Adapted to use in High Schools and Academies. With 149 illustrations. By LE ROY C. COOLEY, A. M., Prof. of Nat. Scienco in the N. Y. State Normal School. Pp. 315. New York: Charles Scribner & Co., 654 Broadway.

The author discourses of molecules and molecular motions, having cut adrift the ancient theory of imponderables. He has no respect for error because it is venerable, and he gives it no room in his book. He sets a good example to the *compilers* of school-books of science.—*Chemical News.*

DICTIONARY OF ENGINEERING, CIVIL, MECHANICAL, MILITARY, AND NAVAL, WITH TECHNICAL TERMS IN FRENCH, GERMAN, ITALIAN AND SPANISH. E. & F. N. Spon. London: 1869. Part I.

This work appears, upon a cursory examination, to be full of useful and *modern* practice. It is very liberally and well illustrated. The "Engineer" and other authorities criticise some of its articles very freely, but all of them, on the whole, commend it. It cannot fail to be important and valuable.

UNDERGROUND LIFE, OR MINES AND MINERS. By L. SIMONIN. TRANSLATED, ADAPTED TO THE PRESENT STATE OF BRITISH MINING, AND EDITED BY H. W. BRISTOW, F. R. S., of the Geological Survey. Illustrated with many plates, including chromo-lithographs. London: Chapman & Hall, 1869.

This is a beautifully printed and illustrated work, and will prove very entertaining to all readers, professional or otherwise.

THE RAILWAYS OF INDIA, WITH AN ACCOUNT OF THEIR RISE, PROGRESS AND CONSTRUCTION; WRITTEN WITH THE AID OF THE RECORDS OF THE INDIA OFFICE. By EDWARD DAVISON, Captain, R. N. London: E. & F. N. Spon. 1868.

THE CHEMICAL NEWS, Vol. IX, 1869. The papers in this volume are, so far, interesting to all classes of readers, especially the articles on food, sewage and water supply.

SANITARY SIFTINGS, OR RESULTS OF SEWAGE SYSTEMS COMPARED. London: E. and F. N. Spon, Charing Cross.

THE A.B.C. SEWAGE PROCESS. London: Yates & Alexander, 7 Symonds Inn, Chancery Lane.

NAVIGATION AND NAUTICAL ASTRONOMY.—J. Merrifield and H. Evers. 8vo., 14s.

COURS DE CHIMIE AGRICOLE. Par M. G. LECHARTIER. Paris.

VESUVIUS. By JOHN PHILIPS, M. A. Oxford: 1869.

COURS DE MÉCANIQUE. Par M. EMILE LECLERT, Paris.

MISCELLANEOUS.

TABLE OF FRENCH AND ENGLISH WEIGHTS.

From "The Engineer."

Kilos.		lb.	lb.		Kilos.
0.500	=	1.1028	1	=	0.4534
1.000	=	2.2055	2	=	0.907
2.000	=	4.4110	3	=	1.360
3.000	=	6.6165	4	=	1.814
4.000	=	8.8220	5	=	2.267
5.000	=	11.0275	6	=	2.721
6.000	=	13.2330	7	=	3.174
7.000	=	15.4385	8	=	3.627
8.000	=	17.6440	9	=	4 081
9.000	=	19.8495	10	=	4.534
10.000	=	22.0550	15	=	6.801
11.000	=	24.2605	16	=	7.255
12.000	=	26.4660	17	=	7.708
13.000	=	28.6715	18	=	8.161
14.000	=	30.8770	19	=	8.615
15.000	=	33.0825	20	=	9.068
16.000	=	35.2880	28=1 qr.	=	12.695
17.000	=	37.4935	56=2 qrs.	=	25.391
18.000	=	39.6990	84=3	=	38.087
19.000	=	41.9045	112=4	=	50.782
20.000	=	44.100			

Cwt.		Kilos.	Tons.		Tonnes.
1	=	50.782	1	=	1.0157
2	=	101.564	2	=	2.0313
3	=	152.347	3	=	3·0470
4	=	203.129	4	=	4.0626
5	=	253.912	5	=	5.0782
6	=	304.695	6	=	6.0939
7	=	355.477	7	=	7.1095
8	=	406.260	8	=	8.1252
9	=	457.042	9	=	9.1409
10	=	507.825	10	=	10.1565
20=1 ton=1,015.649					

Avoirdupoise.

1 oz.	=	28.3380 grammes
1 lb.	=	0.4534 kilogrammes
1 qr.	=	12.6950 kilogrammes
1 cwt.	=	50.7800 kilogrammes
1 ton	=	1.015.650 kilogrammes
1 gramme	=	15.438 grs. troy=0.0353 oz. avoirdupois
1 kilogramme	=	2.2055 lb.
1 tonne	=	0.9846 ton=19 cwt. 2 qr. 21½ lb.
1s. per lb.	=	2.757f. per kilogramme
1f. per kilogramme	=	4.353d. per lb.
£1 per ton	=	24.615f. per tonne.

Moving City Blocks.—In the new Boston improvements, this is accomplished in the following manner: About six houses, or one hundred and twenty feet long, are usually raised in one block together, the walls, front and back, being cut, or rather a line of separation being made at about each sixth house. The raising is done by screws, as usual, and the blocking is the usual cob-house work of pieces of timber. The moving is on wooden rollers, round iron bars, and on balls, with no apparent reason for choosing or using either. Of course, those houses at the ends of each block, in raising, where the party wall is removed, are carefully clamped and braced. And about every fourth house has been found to require the front and back walls to be clamped by through bolts to the floors. The walls may be said to be universally but eight inches—one brick thick. *About one-half the houses are occupied,* the raising or moving not interfering with the domestic comforts of the household. From an examination of the buildings, very few cracks are discernable. The ground is fortunately all solid, not "made," and the underpinning is either done in brick or in cubical granite blocks.

Submarine Blasting at Hell Gate.—The apparatus designed for drilling the sunken rocks for the introduction of the charge, consists of a water-tight iron casing, in form a depressed semi-spheroid, seven feet in diameter. It has three solid steel feet by which its stability on the rock is secured. Rising from the upper part of the casing is a conical wrought iron frame, supporting the upper end of the drill shaft by means of two parallel rods entering into sockets in a cast ring at the top of the frame. The drill bar passing up through the center of the top is furnished at the bottom with a bit, one and a half inches diameter, having imbedded in its face nineteen diamonds, and rotating at the rate of from 300 to 500 revolutions per minute, advancing at the rate of from one to one and a half inches in the same time. The feed is caused by a differential gearing which steadily operates to advance the drill into the rock, the debris being washed away by the water forced into contact with the bit through a small rubber hose. The water-tight chamber of the machine contains a pair of engines working at right angles to each other, with a horizontal stroke. As soon as the hole is completely drilled, and also when the drill shaft is withdrawn from the rock, information of this is given by a magnetic bell which is acted upon by a double wire cord insulated from the water and passing down one of the parallel rods or tubes upon which the crosshead is fixed. This drill weighs nearly five tons. It is worked from a wrecking tug with a derrick by means of steam supplied from the boiler of the tug. To prevent this steam being condensed in its passage through the water to the engine it is conveyed in a hose surrounded by another through which the exhausted steam passes. The rock at Hell Gate is that known as the bastard granite, and is much softer than either the Quincy or Maine granite, on which the drill has been satisfactorily tested. After a number of holes are drilled over a certain space, a diver descends and charges them with cartridges of nitro-glycerine, which is exploded in the usual manner. The fragments are raised by automatic grapnels.

Opinions Differ.—A prominent London cotemporary says about two inventions, one English and the other American, both of which are recognized by the best and most numerous authorities as among the most successful improvements of modern times, as follows:—

Siemens' furnaces do not gain in favor. Those put down at the Woolwich Gun factory are not used, as they were not economical. In Prussia, we understand that they make no way, and the statement is indirectly supported by another which has reached us to the effect that, although used at Elswick, they cost 30 per cent more in fuel than the common furnaces.

Mr. Isherwood, the chief engineer of the United States navy, has reported dead against the monitors, and the secretary of the United States navy cooly suppressed this portion of the report. The American government are building no monitors, and both the Dictator and the Puritan have been pronounced total failures. Turret ships are increasing in favor in Europe, but they must not be confounded with the Ericsson monitor, which is a very different thing.

Trial of Steam Rollers.—A successful public trial has been made at Rochester of a steam road roller, manufactured by Messrs. Aveling and Porter, for the city of New York. An incline having a rise of 1 in 12, was chosen for the trial, its entire surface being covered with the ordinery stones used on macadamised roads. In six hours the road was completely smooth and fit for the passage of vehicles. Messrs. Aveling and Porter have in hand three similar rollers for the Indian authorities.

WESTERN RIVER NAVIGATION.—The Pittsburgh "Chronicle" gives the following figures concerning the number and tonnage owned in the different States along the Mississippi and its tributaries:

	Barges.	Steam vessels.	Total tonnage.
Louisiana	33	230	55,328.67
Mississippi	..	15	2,396.33
Tennessee	..	63	13,412.83
Kentucky	14	75	27,372.83
Missouri	98	210	112,123.18
Iowa	28	28	5,002.29
Minnesota	87	53	18,982.01
Illinois	99	72	27,323.65
Indiana	..	26	5,293.88
Ohio	70	165	98,714.45
West Virginia	20	124	22,115.42
Pennsylvania	385	197	93,152.03
Total	834	1,263	481,217.61

HOT PRESSED NUTS IN ENGLAND.—American machinery for making nuts has been introduced in Birmingham. The process may be thus briefly described: The puddled iron is placed in a reverberatory furnace, rolled to the requisite size, and while still hot is placed in the machines. Here the iron is cut off, forced into a die box, either square, hexagonal, or octagonal, as the case may be, and while under the necessary pressure it is punched simultaneously from either side. The advantages of this process are the greater cohesive strength arising from the hole being forced into the nut, thereby solidifying the metal; the certainty with which the hole is made exactly central, as well as smooth and true throughout; the regularity and quality of the angles; complete uniformity of size; and rapidity of production. Fifty to eighty nuts can be produced per minute. Bolts are produced by other machines at a single blow.

NOVEL USE OF THE CAMERA OBSCURA.—Some officers of engineers have just been making experiments at Antwerp as to the means of defending the passes of the Scheldt by a system of torpedoes placed in three lines, the explosion of which is regulated by the use of a camera obscura. The instrument is fixed at a certain point, and whenever a ship passes over it, its image is reflected on the mirror at the camera. When the image arrives at a certain determined point, the eclectric current is applied, and the explosion takes place immediately. The mines are numbered, and each has a corresponding mark in the chamber. The method of observation is simple and sure, and was adapted for the defence of Venice in the late Italian war. The trials succeeded perfectly, and are soon to be repeated on a larger scale.

TWENTY-FOUR POUND BOAT.—Walter Brown, the champion oarsman, has lately built a single scull outrigger shell of Spanish cedar, 30 feet seven inches long, twelve inches wide, and six and three-eighths inches deep amidships; four feet and eleven inches wide across the rowlocks, eight inches deep aft, and four and a half inches forward; weight 24 pounds. She is nearly finished now, and weighs only eighteen pounds. He is building another boat of the same size, which will weigh only nineteen pounds. The lightest boat heretofore built, of the same size, was that in which Brown rowed at Pittsburg last September. This was made of paper, and weighed $27\frac{1}{2}$ pounds.

SCREWS VS. PADDLE.—The Cunard paddle steamer Persia has been turned into a sailing vessel with auxiliary screw. The Cunard paddle steamer Scotia is to be converted into a screw.

PAPER ON CONSTRUCTION.—We have in type the first of a valuable series of articles on this subject, which will extend through several numbers of the magazine. Various papers on construction are in course of publication, in the home and foreign serials. While they are generally useful, we think that some of them are too elementary, others too abstruse, and others still too limited in scope to meet the requirements of our readers. A compilation of such miscellaneous elements would hardly answer the purpose. We have therefore secured the preparation of a series of *original papers*, by an engineer officer, whose education and practice have thoroughly fitted him for the work.

THE ROGERS LOCOMOTIVE WORKS employ 3,000 hands, and turn out about ten locomotives per month, besides an immense quantity of cotton and woolen machinery. The works comprise one building 200 by 32 feet, and one 102 by 40, with boiler shop, erecting shops and several other structures. This establishment was founded in 1831 by Thomas Rogers, and turned out its first locomotive for the Mad River and Lake Erie Co., in 1838.—*American Railway Times.*

WORKS FOR UNLOADING COAL AT NEW HAVEN.—Hawkins, Herthel and Burrall of Springfield, Mass., have a contract, amounting to upwards of $40,000, for building a new coal wharf for the Hartford and New Haven railroad at New Haven. In connection with the wharf, which is to be 1,000 feet long and 50 feet wide, will be four elevators, capable of storing 1,000 tons of coal.

THE BOSTON ELEVATOR, building by the Boston and Albany Railroad Co., is constructed of brick and wood; it is 70 feet high. The upper story will contain 82 bins; the total capacity will be 250,000 bushels. It is stated that a car can be emptied in ten minutes, and that the cost of elevating and storing will be one cent per bushel for the first five days, and storage extra after that time.

BLASTING GRANITE.—In one of the granite quarries, near Penryn, a large mass of sound granite has been moved from its natural bed some inches, by 50 lb. of blasting powder, confined in a hole 12 ft. deep and $6\frac{1}{2}$ in. in diameter, bored in the rock. The stone measures, at least, 40 ft. by 40 ft. by 12 ft., which equals 19,200 cubic feet, or 1,280 tons.

THE MERCANTILE LIBRARY of New York has now 100,000 volumes, embracing the best works on every topic. Popular works are largely duplicated, and about 10,000 volumes are added yearly. The reading-room is large, well-warmed, well-lighted, and supplied with 3,000 books of reference, and over 400 periodicals, foreign and domestic.

ELECTRIC CLOCKS.—Kennedy's, exhibited in New York, are driven by the current of an earth battery, and require no winding up. All the clocks in a house or locality, or on a line of railway, may, it is alleged, be driven by the same battery, and keep the same time, tick for tick.

STEAMSHIP CONSTRUCTION.—The promised article treating this subject generally, has been crowded out by two articles referring to the marine engine particularly—the Hercules, and Morton's Condenser—but will appear in our next number.

THE P. AND O. FLEET.—The steam fleet owned by the Peninsular and Oriental Company comprises a total of 48 ocean-going vessels, having an aggregate tonnage of 85,632 tons and 18,520 horse power.

VAN NOSTRAND'S
ECLECTIC
ENGINEERING MAGAZINE.

No. IV.—APRIL, 1869.—Vol. I.

FRENCH NAVAL ENGINES.

CRITICISMS AND ANSWERS—LIGHT MARINE ENGINES—HISTORY OF HIGH EXPANSION—NORMAND'S SYSTEM.

Translated from "Annales du Génie Civil."

In our last number we published the sharp criticisms of "Engineering" on our navy. M. Belleville, in a discussion of a memoir of M. Normand, has replied to these criticisms which, under the influence of a patriotic anxiety, have been much exaggerated; and our readers will see that if, as MM. Mallet and Normand have shown, we can improve vastly in the engines used in our ships, we have long been in advance of other nations in the improvements made upon hulls and propellers. MM. Normand and Mallet intended in their memoir to give an accurate *resumé* of all the improvements which have been made in marine engines, and a table showing the progress made at the principal centers of ship building in the Old World and the New, and they proposed to show the arrangements which must be adopted in marine machinery, if we expect to get rid of the errors in vogue among naval engineers. The problem of the best system of marine machinery consists entirely in the determination of the best results in three classes of economy. We give them in the order of their relative importance: 1st. Economy of weight. 2d. Economy of fuel. 3d. Economy in expenses of capital, in repairs, in the *personnel* and accessory expenses. These various kinds of economy are not inconsistent with each other.

MM. Mallet and Normand have summed up in four graphic tables the results obtained by experiment from more than one hundred engines. The first represents the weights of the machinery complete (engine, boiler, water and propeller) in horse powers of 75 kilogrammeters measured by the indicator on the pistons. The second shows the actual development of power measured by the indicator per nominal horse power. The third shows the consumption of fuel per indicated horse power of 75 kil. met. The fourth shows the total weight of the entire machinery, with fuel enough for five days' steaming with maximum power. Each of these tables will show at a glance the great difference in the results given by the various systems which are or which have been in use. We may thus determine the disadvantageous position occupied by the French navy with respect to its prime movers. This inferiority has been general for a quarter of a century, and is continually getting worse. It is an indisputable fact to-day that the English vessels recently built can develop an actual power nearly double that of the vessels in the French fleet. The development per nominal horse power which in the Imperial marine has never yet reached 300 kil. met., is fixed for the new English vessels at 450 and in some of them exceeds 500 kil. met.

The weight of engines per unit of actual power is the most important question, and it is upon this point that the widest differences with respect to economy occur. The total weight of the machinery, including boilers, may be resolved into its elements. The steam generating apparatus, consisting of elements in some sort alike (grates, flues or boilers), differ only in the number of parts. The total weight of boilers and water is then, for each system, sensibly proportional to the power to be developed. In the engine proper the case is different—for the same system the weight varies in a higher ratio than the power. Notwithstanding the many modifications introduced into the construction of engines and boilers, the ratio between the fraction of weight which is always constant, and the fraction which varies with the velocity of the engine, is not sensibly changed. In taking for a unit of weight the weight due to a velocity of one revolution per second, we may express the relation for all other velocities by the formula—

$$P = \frac{2}{3} p + \frac{1}{3n} p.$$

The following figures indicate the total weights per indicated horse power, corresponding to each of the great classes of marine engines:

No. of revolutions per minute	15	20	30	60
Old beam engines with flue boilers	660 kg.	550 kg.	440 kg.	330 kg.
Direct acting engines with tubular boilers.	420	350	280	210
Same engine of John Penn's system	300	250	200	150
Limits of the lightest engines of the present day	240	200	160	120

These figures show the vast progress made during the last 25 years in reducing the weight of machinery. Between the first Cunard packets and the present transatlantic propellers the weight has undergone a reduction from 660 kil. down to 180. This reduction is the result of three forms of progress: 1st. The substitution of tubular for flue boilers. 2d. The substitution of direct acting engines for more complicated ones. 3d. The greater rapidity of revolution, due partially to increase in the velocity of the vessels, but especially to the substitution of the propeller for the paddle. Beside those considerations belonging to the degree of excellence in the construction, such as the forms and proportions of the various parts, the use of stronger materials which will allow a diminished thickness, the weight per unit of power developed, &c., the ultimate economy is largely dependent upon the functional action of the steam upon the engine. The conditions of lightness are much improved in large engines by a more advantageous use of the steam, and by the better draft obtained by high chimneys, which can be employed only on large vessels.

Altogether, the results obtained by MM. Normand and Mallet may be summed up as follows:

The old low-pressure flue boilers weigh, on an average, 250 kil. per indicated horse power, and 20 kil. per kil. of steam per hour. In the greater portion of the boilers of Imperial type, these values are reduced to a mean of at least 140 and 13 respectively. In English machinery these weights are only 110 and 10 kil. respectively. In the boilers of the Francis I, built by M. B. Normand, the exclusively cylindrical forms given to the shells and grates, together with the substitution of steel for iron plate, have reduced the weight to 7 kil. per kil. of steam per hour. The combination of these steam generators with the economically working engine has reduced the weight per indicated horse power to 50 kil.—an economy which has never before been reached in any marine boiler.

M. Normand then proceeds to inquire into the conditions which regulate the weights of the other parts of marine machinery, viz: the engine proper and the propeller. Nearly every part has at least one of its dimensions determined by the intensity of the effort which it is to receive or transmit; the weight of every mechanical part then should be sensibly proportional to the amount of work developed by a single revolution. The final development of power as related to the time being proportional to the rapidity of revolution, which in turn is governed by elements dependent upon the vessel, the correct value of the conditions of lightness will be furnished by an expression which MM. Normand and Mallet have employed for the first time (so far as they know), in these investigations. It consists in approximating the weight to a standard corresponding to a uniform velocity (or speed), the weight being inversely proportional to the power due to two-thirds the number of revolutions. Two tables furnished by MM. Normand and Mallet give the economy of weights in paddle and screw engines. In beam engines with paddles, the weight is 1.5 kil. per kil. met. of indicated work per revolution. This weight is between 1 kil. and .80 kil. in a majority of the modern direct acting engines, and in the lightest on the Penn plan it is as low as .60 kil. The weight per indicated horse power shows some extreme variations in consequence of the introduction of another element of inequality, viz: the variable rate of the engines. The weight corresponding to a horse power of 75 kil. met., which in the old beam engines often reached 350 to 400 kil., does not exceed in the most perfect modern engines 150 kil. for the large ones, nor 100 or even 70 kil. for moderate sized and small ones. Screw engines, even the more recent ones, show similar diversity in the economy of weight. The graphic tables alluded to show clearly the errors and mistakes in construction already pointed out by M. Normand. The engines of the Imperial marine are classed between 1.60 and 1.20 kil. per kil. met. per revolution, while the engines of Penn and Maudslay do not exceed .80 or even .70 kil. For weights per indicated horse power, almost all the engines of the Imperial marine are between 150 and 110 kil., while the English builders just cited do not exceed for the largest engines 70, or perhaps even 60 kil. John Penn, in the yacht Le Grille (engine of small size and great speed), has reduced this weight to 30 kil.

But the question of economy of weight in steam engines is intimately connected with that of the advantageous use of steam and consequent economy of fuel. The once admitted laws of expansion are acknowledged to be incorrect, and the tables of cut-off now in use stand in need of correction. MM. Normand and Mallet present a new table of cut-off which they have collated, keeping in view the three following classes of corrections: 1st. For the reductions of temperature corresponding to varying pressure. 2d. For the portion of steam condensed, which, with the reduced temperature, makes up the loss of heat corresponding to the work done. 3d. For the resisting pressure of the condenser. In the calculation of heat consumed by the work done, each unit of heat (*calorie*) has been calculated as corresponding to 400 kil. met. The back pressure of the condenser, which varies from three to six per cent of the boiler pressure, has been made equal to four per cent of the initial pressure. By economy of agents (*organes*) the authors mean the relation existing between the mean effort of the whole stroke of the piston and the maximum effort under initial pressure. The data of cut-off have been made to correspond with the performance of a majority of marine engines with an admission of $\frac{2}{3}$, and not with an admission over the whole length of stroke. Finally, the table has been calculated for an initial pressure of five atmospheres. The values should be slightly increased for lower pressures and diminished for higher.

It must be inferred from these tables that all engines constructed up to a very recent date, however different in plan, show no differences in the economy of steam, at least as to the maximum useful effect obtainable from it. If differences occur, they are the reverse of economy. Notwithstanding the marked increase in the tension of steam, which in the last 20 years has been raised from $1\frac{1}{2}$ to $2\frac{1}{2}$, or even 3 atmospheres, no economy of fuel has been obtained. On the one hand, the experiments of a $\frac{2}{3}$ expansion have led only to mistakes, and on the other the increase of pressure has been offset by disadvantages in the distribution and condensation of the steam. These disadvantages are most conspicuous in engines at high speed. The ordinary marine engine gives an indicated horse power with a theoretical expense of 12 kil. of steam, which represents a consumption of $1\frac{3}{4}$ to $2\frac{1}{2}$ kil. of coal.

At the commencement of this state of affairs it was conceded that the expansion principle offered a boundless field of improvement. Yet it was thought (and perhaps not wrongly) that it would be well to imitate the most advanced products of ingenuity and use the most economical kinds of engine, particularly the draining engine of Cornonailles and the Woolf engines, the cost of which was about half that of the marine engine of that day. But the objections were many. One of these types was heavy, cumbersome, complicated; the double expansion was impracticable on the water, and the pressure must not exceed a defined limit. Facts have demonstrated that an economically working engine not only can be built within the conditions of weight of engines of high expansion, but that a more perfect action of the steam may be a source of still further progress in the economy of weight.

The following history of progressive improvements is succinctly given by MM. Normand & Mallet.

In 1856 Rowan & Horton constructed marine engines on the Woolf plan, with surface condensers, and working at a pressure of 8 or 9 atmospheres, which, however, was practically found to be inconvenient. Randolph & Elder endeavored to increase the expansion by the use of larger cylinders instead of augmented pressure. They succeeded in obtaining good results with expansion under a pressure not exceeding 3 or perhaps $2\frac{1}{2}$ atmospheres. In 1861, Humphreys, following the same path, introduced engines with large cylinders, having small ones superposed. The English engine builders all agree in using a large amount of expansion with surface condensers, steam jackets and superheating. Lastly, M. Normand claims to be the representative of French ingenuity in this struggle for maritime progress, and some significant facts seem to show that the improvements which he was the first to elaborate and carry forward successfully cover the greater part of the problem of the economical marine engine. His attempts go back as far as 1854. The main idea in the Normand system consists in dividing the total expansion between two cylinders, which are entirely independent of each other in respect to their movements, though capable of attachment to the same shaft by cranks at right angles, an essential feature in the marine engine. These cylinders communicate with an intermediate reservoir, where the steam escaping from the first cylinder is relieved of the condensation resulting from the work done, and receives a certain addition of heat before entering the second cylinder. This simple plan constitutes a marine engine with all the advantages of a double expansion and without any increase in the number of parts. It can with suitable modification be applied to any existing engine, and has already been used in small vessels of high speed. With respect to economy of steam its superiority is very decided. With a cut-off at $\frac{1}{4}$, the economy is .92 against .52 in ordinary engines. With a cut-off at $\frac{1}{10}$, the economy is still .54 against .26. The average admission in the two cylinders of M. Normand was in the first .65 and in the second .40.

The advantages of M. Normand's system were officially recognized in 1860 by a commission appointed by the minister of the marine. One of his engines was placed upon the transport Loiret, of the Imperial navy. It had the double expansion, the independent movement of the pistons, with the intermediate reservoir for drying and reheating the steam. Subsequently it was put into a number of frigates with 950 nominal horse power, and into four corvettes, with 450 nominal horse power, &c., &c. He has also applied his system to some fifty engines, marine and stationary, with even better results than those obtained in the navy, though the principles are the same. It was in some engines built in the government dock yards that he obtained the highest actual power, and that with a large expansion and no increase in the size of the cylinders, making a saving of 500 indicated horse power. This is the mean deficiency of the armored frigates, and it serves to show how erroneous have heretofore been the principles upon which their engines were constructed.

With respect to economy of fuel, results have been more favorable. The consumption has been reduced to 1.44 kil., while in the engines built by M. Normand himself this consumption is still less by one-fourth. We give below the relative values of the cut-off in various systems:

	Cut-off at—	Saving.
Old marine engines . . .	$\frac{2}{3}$	1.
Dupuy de Lôme	$\frac{2}{5}$	1.30
Normand	$\frac{2}{9}$	1.60
Humphreys	$\frac{1}{6}$	1.74
Rowan & Horton	$\frac{1}{8}$	1.84
Randolph & Elder . . .	$\frac{1}{10}$	1.90

If it is desired to obtain the greatest lightness of engine with the greatest economy of fuel, the cut-off should be varied according to the distance to be run. M. Normand gives the following table:

1 day,	rate of	expansion,	4 or	5	volumes.
5 "	"	"	5 or	6	"
10 "	"	"	6 or	7	"
15 "	"	"	7 or	8	"
20 "	"	"	8 or	10	"

In view of the faulty imitations of his work, M. Normand finds great pleasure in presenting the results of an engine put into the Francis I—a passenger vessel running between Havre and Trouville, or Honfleur. The nominal power is 100 and the developed power 550; consumption of fuel per indicated horse power, 1.10 kil.; speed, 26 kilometers; boilèr pressure (*le timbre des chaudières*), 4 atmospheres. Total weight of machinery, including 11,000 kil. of water, 56,500 kil.

The Normand system has just been adopted by the General Transatlantic Company for their packets of 450 horse power, which are to be built for their new Pacific line.

As a supplement to the communication of M. Normand, and his observations on the law of the pressure of expanding steam, M. Duprez has published the results of some calculations relative to the work of 1 kilogramme of steam in high pressure engines without condensers, and where the expansion is carried on until the tension becomes equal to 1 atmosphere. The following are the resulting ratios of heat utilized to heat expended:

Initial pressure in atmospheres	8	10	12
Ratios	0.1501	0.1633	0.1771

Hence the increase of useful effect would be 18 per cent if the pressure were carried to 12 atmospheres instead of 8; in other words an engine working at 8 atmospheres and consuming 100 kil. of coal would consume only 84.7 at a pressure of 12 atmospheres, with an expansion to a pressure of 1 atmosphere. The advantage would be still greater if the final pressure were as low as it is in marine engines. These results are in accordance with the method laid down in the work of M. Combes on the mechanical theory of heat, but it assumes that there is no loss of heat by conduction and radiation.

M. Belleville, who has been connected with the Imperial marine since 1853, has obtained meantime some accounts which he thinks do not harmonize altogether with the views of MM. Normand & Mallett. The value of a war vessel does not depend solely upon the greater or less effective force of her engines as compared with their nominal power, nor yet upon the diminished weight of machinery, but as well upon the economy of power, speed obtained, facility of evolution, resources of battery—in short, upon whatever determines fighting qualities and seaworthiness. In 1850 no navy in the world had steam vessels capable of competing with the old sailing craft. England had three or four steamers used as a coast guard, which might sail, with steam alone, 7 knots. At this juncture was launched at Toulon the first steamer which was to solve the vexed problem of great speed united to all of the sea qualities possessed by the better class of sailing vessels. The Napoleon, a product solely of French naval engineering, and furnished with an engine of 900 horse power (nominal), the largest then in existence, has justified all expectations. This purely French achievement served as the type for the creation of new fleets, both in France and elsewhere, and the Napoleon is still considered one of the best wooden war steamers afloat. Her excellent results have been achieved not only in experiments but in actual service. During the Crimean war, when the French squadron were ordered to pass the Dardanelles, the Napoleon, having in tow the three-decker Ville de Paris, accomplished it easily in the face of a powerful head wind which compelled the English fleet to anchor and wait a whole week for favorable weather. After the launch of the Napoleon, England put the Agamemnon upon the stocks—a vessel of the Napoleon type, of almost identical dimensions, and differing only in a little lighter draught. The Napoleon had 2.602 indicated horse power, the Agamemnon 2.206; the speed of the former is 13 knots, of the latter 10 knots. The co-efficients of useful effect are respectively 2.125 and 1.86. In France all vessels put upon the stocks by the Imperial marine were built upon the plan of the Napoleon. In England the same sort of idea was followed, with some variations. The experimental vessels Algesiras and Marlborough offered a further comparison:

	Ind. H.P.	Speed.	Useful effect.
Algesiras	2,696	13.37	2.244
Marlborough	2,718	11.5	1.86

With one-half fires the Algesiras gave 1.742 horse power and 11.66 knots, with a coefficient of useful effect 2.306.

In 1856 the French naval engineers built the armored frigate La Gloire—an undertaking ridiculed by English engineers and scribblers. Their criticisms also became known in France. But the results have vindicated the promoters of this bold project. The plated floating batteries which had been built in France and England after the Crimean war were merely floating forts, while armored vessels having the sea going qualities of wooden ones were then altogether unknown. In this matter England followed the example we set her, and started the construction of a fleet upon our new ideas.

M. Belleville has acquainted us with the composition of the two fleets, showing for each vessel the power, speed and coefficient of useful effect, and from his tables he derives the following mean results for armored vessels:

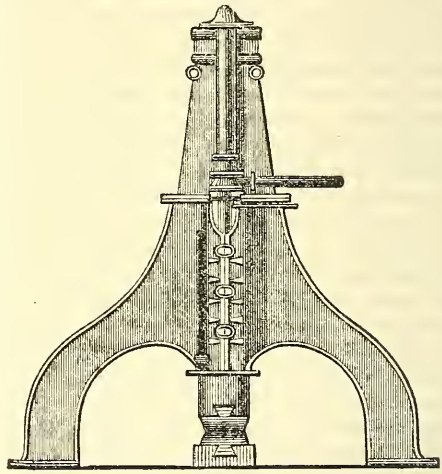
	Speed, knots.	Coeff. of useful effect.
French	13.718	2.176
English	12.939	1.878

On the whole France has led the march of improvement for the last 15 years. Successive engines have been perfected in the Imperial works in which the weight has been reduced and the consumption of fuel decreased. At present the Woolf engines are used, and the consumption of fuel has been reduced to 1.3 kil. on the Magnanime, and to 1.240 kil. on the Jeanne d'Arc, and that without surface condensers. M. Belleville is confident that all the new engines will be provided with surface condensers, and that before long steam at high pressure will also be used, which has not yet been done except upon gunboats and similar structures. Finally, M. Bellville believes that M. Normand's figures relating to the indicated power of the French fleet are too small, while those relating to consumption and to the weights are too large. M. Flachat remarked that M. Belleville did not answer directly the observations of MM. Normand and Mallet, who had examined exhaustively only the marine engine.

Progress in this branch of science has been gradual. First came the screw, with engines of quick stroke and consequently small dimensions; then steam jackets, superheating, surface condensation, and finally high pressure with high expansion. The surface condenser enables the boiler to be fed with distilled water, and prevents incrustation, making the iron plates better conductors of heat and more durable. This step in advance was accomplished in England by MM. Randolph and Elder, but M. Normand had urged it long before, and has finally established it in France in the face of difficulties which the Englishmen did not have to encounter. M. Flachat reviews the successive transformations of marine steam engines, and shows that the Transatlantic Company, whose origin does not go far back, is now making its third transformation. After nine years' service the Royal Mail is also, after a most varied experience, exchanging paddles for screws, with the boilers of Randolph and Elder. The history of the Imperial Company, of the Peninsula and Oriental, of the Cunard—in short, of all companies, is but a long series of renovations and progress. This summary of facts which daily modify our naval material shows the technical importance of the questions to which MM. Normand and Mallet have drawn the attention of the Society. In England progress in this path is very rapid, but in France there are administrative regulations applying to the marine boiler of large diameter and high pressure. It is fortunate that locomotive engines have smoothed the way in this respect, and that the recent progress in the fabrication of plate iron came seasonably to aid in the solution of this question.

MM. Normand and Mallet present some remarks in reply to the strictures of MM. Belleville and Flachat. They state that M. Belleville speaks of vessels in their *ensemble*, while they have confined their investigations to the machinery. They accept some numerical corrections of M. Belleville, as to the power of engines, but insist the correctness of the sources whence they derive their figures should be admitted. They adhere to what they have said as to the inferiority of French engines, in which the useful effect reaches but two-thirds or perhaps only one-half the standard of the English marine.

IMPROVED STEAM HAMMER.—The engraving shows a new style of fifteen ton steam hammer, by Messrs. Thwaites & Carbutt, of Bradford, England.

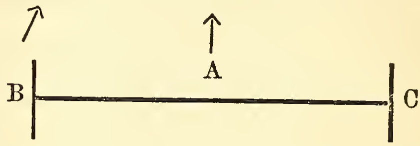


The peculiarity of this hammer consists in joining the standards, which are of the best patterns, boring them out, and putting in a round core. This gives great strength and stiffness, besides more efficiently guiding the hammer. The standards, which are 20 tons in weight, are 20 ft. apart, and give 8 ft. 6 in. headroom. These are bolted to a bed plate made in three pieces, and are also fastened by wedges driven between the lugs, which are cast on the plate. A balance piston valve is placed in the same casting as the stop valve, so as to save the joints of a separate stop valve. The anvil weighs 120 tons, and is placed on two rows of 18 in. sq. oak, laid in a cut stone foundation. The foundation of the block is kept as separate as possible from the side-wall foundations for the bed plate which carries the standard, so that the jerk and spring of the one is not communicated to the other.

IMPROVED RAILWAY RUNNING GEAR—LOOSE WHEELS.

Among the many barbarisms that characterize our railway practice, the sliding of half the wheels in a train, upon every curve in the line, by reason of their rigid connection to the axle, is one of the most wasteful, although it has been one of the most difficult to overcome. Lines of easy curves are not exempted from the evils resulting from the greater length of the outer rail. It is not so much the sliding of a wheel a few feet more or less, after it is started, but it is the starting of the slipping, that consumes power and material, and brings the sudden and heavy torsional strain upon the axle. Even on air lines, the difference in the diameter of wheels—often amounting to ½ inch in one revolution—keeps the axle in an almost perpetual state of torsional strain, and wears the tread of both rail and wheel by an unbroken series of little scrapings, from one end of the road to the other. But the wear is not the only evil. The lurching and jarring of the whole running gear from this cause, and more especially the twisting of the axle back and forth at every curve, thus seriously weakening an iron axle, if not excessively heavy, require a degree of massiveness and non-paying load that could be greatly reduced by making the wheels independent. Precisely what the saving in friction might be, it is impossible to state, because we have no prolonged tests of a thoroughly practicable apparatus. But it is reasonable to assume that with the present apparatus the friction and the general wear and tear of running gear, and the extra non-paying load thereby made necessary, add at least 20 per cent to the normal power required for traction.

Many devices to meet this difficulty have been tried, and many more have been invented. The most obvious direction of improvement is in using a simple loose wheel. One wheel has been cast with a deep hub, so as to give a long bearing on the shaft, and some experimenters have even gone to the trouble of fitting boxes into the hub to take up the wear. But after every nicety of fitting and adjustment, the car had a perverse, uniform, incurable, and, to most experimenters, inexplicable tendency to run off the track; the wheel fastened to the axle was always crowding the rail. This tendency cannot be cured; it can only be avoided by abandoning this plan altogether. A simple analysis of the forces will make this evident. The two axle-boxes and the superincumbent load rest upon the two ends of a continuous axle. Upon one end of this axle a wheel is rigidly fastened; upon the other end there is a loose wheel. In the first place let us suppose that the axle, B C in the diagram, instead of being free to move in the axle-boxes, is rigidly held by them, so that it cannot turn. A power is applied, in the direction A, to the middle of the truck. Since the wheel C cannot turn,



it will tend to slide, and thus require a great exertion of power. But the wheel B can turn, and the end B of the axle, and with it the truck, will be pulled in the direction of the arrow B, while the end C will stand still. It is a simple case of a lever with the fulcrum at C and the power at A. Now, if we loosen the axle-boxes a little, so that the axle will just be able to turn in them, the effect will be the same in kind, but less in degree. The power required to turn the axle in the axle-boxes is still so much in excess of the power required to turn the loose wheel B on the axle, that the end C will be retarded and the truck will run off the track. Just in proportion to the amount of axle friction, will this be the tendency. The forward motion of one side of the truck, or one end of the axle, is retarded by the friction of *both* journals.

This difficulty may, indeed, be avoided by making both wheels loose, but the cost and weight of an apparatus which should give sufficiently long bearings, for safety and stability, would be considerable. Another plan is the division of the axle in the center. The sleeve joining the two ends must be so long and heavy, and the fittings and details for oiling, adjustment, etc., so expensive, that two internal journal-boxes, on a middle beam of the truck frame would perhaps be a better arrangement, and this would be neither cheap nor light.

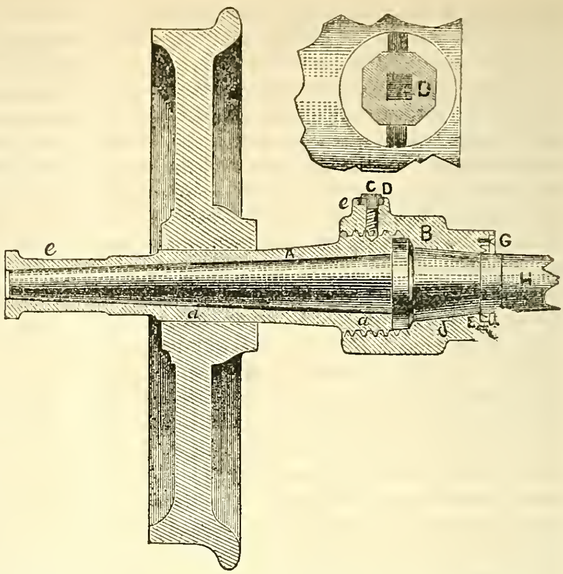
The difficulties we have mentioned have been, we think, very successfully avoided in the axle shown in the engraving.* It is

* Patented by D. M. and A. G. Cummings. Proprietors, Cummings, Wells & Godfrey, Enfield, N. H.

simply a solid iron or steel axle, made smaller at one end to receive a loose steel sleeve, upon which the wheel is fastened, and upon which also the journal-box rests. The opposite wheel is made fast to the axle in the usual manner. The sleeve is 24 in. long, bored at the ends to fit the axle, but counter-bored slightly in the middle to give slight flexibility. The small end of the axle is $1\frac{3}{4}$ in. diameter; the large end of the taper is $3\frac{3}{4}$ in diameter. At this point there is a 6 in. fast collar, from which the axle tapers the other way towards its center. The steel sleeve is held against the collar by a loose collar B, eight inches long, which is screwed upon the end of the steel sleeve. The axle is of the full size, where this loose collar comes, so that the strength is not dependent upon the latter. The collar, however, increases the length of the bearing of the steel sleeve upon the axle to 30 in. The loose collar is kept from unscrewing by the three set screws C (shown in plan in the upper figure), and these set screws are kept from unscrewing, by a washer D fitting into the recessed boss c of the loose collar B. By slightly riveting the opposite corners of the set screw over the washer, the latter is kept in place. Should the bearing between the axle and the steel collar wear, the lost motion may be taken up by withdrawing the set screws, facing off the end of the steel sleeve, and screwing up the loose collar. Oil from the axle-box will be constantly thrown, by centrifugal force, up the inclined portion of the axle, so as to keep all these parts lubricated. The oil may be prevented from escaping, and dust from entering, at H, by means of a hydraulic packing leather and plate G, F. The details have been very thoroughly worked out by a skillful mechanic.

It will be observed that the strength of the axle is not impaired. Although the internal axle is small, the external steel sleeve brings the whole structure up to full size. Experiments upon hollow axles show that the sleeve would be nearly or quite as strong bored out as if solid. The additional weight is chiefly that of the loose collar B.

We learn that several sets of these axles are being fitted up for trial on the Pennsylvania and other roads.



STEAMSHIP PERFORMANCE—THE KŒNIG WILHELM.

In a previous number* we gave the particulars and performances of one of Mr. Reed's new iron-clads—the Hercules. The remarkable results of Messrs. Penn's engines, in this vessel, have been largely commented upon in the technical press. We now quote from "Engineering" some particulars of another of Mr. Reed's vessels—the Kœnig Wilhelm, a new Prussian iron-clad—and the results of the engines of Messrs. Maudslay, Sons and Field, builders of equal renown.

This vessel is 372 ft. 4 in. long over all, and 355 ft. 10 in. between perpendiculars, with 60 ft. beam; being 30 ft. 10 in. longer and 1 ft. broader than the Hercules, while her tonnage is $5{,}938\frac{71}{94}$ tons, being nearly 705 tons in excess of that of the last named vessel. She is provided with an armored battery commencing 42 ft. aft of the fore perpendicular and extending for a length of 232 ft. on the main deck, this battery being protected at the sides with 8 in. armor plates, and at the ends by plates 6 in. and $5\frac{1}{2}$ in. thick. Besides this main battery there is an after battery protected with 6 in. plates, and having a port pointing directly astern; and also armor plated bulkheads on the upper deck. At the water line the Kœnig Wilhelm is protected by a belt

* Van Nostrand's Magazine, Vol. I, No. 3, p. 204.

of armor plating of which the lower edge is 6 ft. 8 in. below the water line amidships and a little less forward, whilst under the counter it rises considerably. The lower strake of this belt is composed of plates 7 in. thick amidships and tapering to 5 in. thick at the extremities, while the remainder consists of plates 8 in. thick amidships, tapering to 6 in. fore and aft. From the particulars we have just given it will be seen that the Kœnig Wilhelm is less heavily plated at the water line than the Hercules, while over the upper part or battery the armor is slightly heavier than that of the latter vessel. The port sills of the Kœnig Wilhelm are 10 ft. above the water line amidships, while those of the Hercules are 11 ft.; and there can be no doubt that the additional free board possessed by the latter vessel would prove of great advantage to her in the event of an action in rough water.

The Kœnig Wilhelm is fitted with a set of three-cylinder engines, by Messrs. Maudslay, Sons and Field, and we think that the performance of these engines during the recent trial must have given unqualified satisfaction to their makers and to all concerned. The cylinders are 95 in. in diameter, with 4 ft. 6 in. stroke, and during the trial they were run at a mean speed of 64 revolutions, and a maximum speed of 65.333 revolutions per minute, corresponding to piston speeds of 576 ft. and 588.117 ft. per minute respectively. The engines are fitted with surface condensers, exposing 17,250 square feet of surface; and steam is supplied by eight boilers, having 22,600 square feet of heating surface, and a fire-grate area of 890 square feet. Although rated at but 1,150 nominal horse power, the engines developed during the trial a mean indicated power of 8,345 horses, whilst during the running of the sixth mile the indicated power reached no less than 8,663.889 horse power, the highest result, so far as we are aware, ever obtained on shipboard with any engines, or under any circumstances; and one on which we think Messrs. Maudslay may fairly be congratulated. We give, on another page of the present number, engravings of the indicator diagrams taken during the sixth run, when the above power was developed, and to these and the particulars which accompany them we refer for more detailed information concerning the performance.

As we have already instituted a general comparison between the Kœnig Wilhelm and the Hercules, it may be interesting that we should similarly compare the engines of the two vessels, constructed as they have been by our two leading firms of marine engine builders. The principal results obtained during the respective trials were as follows:

	Hercules, engined by Penn.	Kœnig Wilhelm, engined by Maudslay.
Revolutions per min, max.......	72	65.333
" " mean......	71.51	64
Piston speed in feet per min, max.,	648	588.117
" " mean,	613.59	576
Mean pressure of steam in boilers,	29.5 lb.	30.5 lb.
" " cylinders,	20.0 lb.	22.483 lb.
Average vacuum*................	27.08 in	27.875 in
Nominal horse power	1200 H.P.	1150 H.P.
Mean indicated horse power	8528.75 H.P.	8345 H.P.
Maximum	?	8663 889H.P.
Number of times the mean indicated exceeds the nominal horse power........................	7.106	7.256

The proportions of heating and condensing surface and fire-grate area to the power developed in the two sets of engines are as follows:

	Square feet per mean indicated horse power.	
	Hercules.	Kœnig Wilhelm.
Heating surface................	2.7	2.9
Fire-grate area................	0.106	0.108
Condensing surface............	2.43	2.067

The draught of the Kœnig Wilhelm, on the occasion of her trial, was 24 ft. $4\frac{1}{2}$ in. forward and 26 ft. $4\frac{1}{2}$ in. aft, while her displacement was 9,542 tons, or 862 tons more than that of the Hercules during the corresponding trial. The area of immersed midship section, on the other hand, was 1,306 square feet, or 9 square feet less than that of the Hercules. For the particulars of the speed attained during the different runs, we must refer to page 135 of the present number, where these details are given, and we need only state here that the true mean speed, as determined by the "mean of means," was 14.499 knots against the speed of 14.691 knots attained by the Hercules. The coefficients given by the respective full power trials of the two vessels are as follows:

	Hercules.	Kœnig Wilhelm.
$\frac{\text{Speed}^3 \times \text{mid. sec.}}{\text{Ind. H.P.}}$	488	477
$\frac{\text{Speed}^3 \times \text{disp.}^{\frac{2}{3}}}{\text{Ind. H.P.}}$	157	164.3

It is, we think, unnecessary that we should comment upon the facts we have laid before our readers, as the remarks which we have on previous occasions made concerning the

* The weather barometer stood at 30.2 in. on the occasion of the trial of the Hercules, and 30.4 in. on that of the Kœnig Wilhelm.

Hercules will apply almost equally well to the Kœnig Wilhelm. This being the case, we need only say that we consider that to Mr. Reed is due the credit of having produced in these vessels the two finest ironclads afloat; and while we cannot but congratulate the Prussians on the possession of the Kœnig Wilhelm, we still more congratulate ourselves on the possession, in the Hercules, of a vessel which we believe to be, in many respects, her decided superior.

NEW ENGLISH LOCOMOTIVES.

In reviewing the late locomotive practice in England, "The Engineer" says that little or nothing has been done that was not done before. The relative merits of inside and outside cylinders remain in dispute. On the Great Eastern system, where Mr. Sinclair employed outside cylinders solely, Mr. Johnson, his successor, is building nothing but inside cylinders, while Mr. Adams, of the North London Railway, who built only inside cylinder engines, is now using outside cylinders. We mention these facts simply to illustrate the diversity of opinion which exists all over the kingdom on this point. So long as cylinders can be kept down to a diameter of about 16 in. the advantage seems to be with the inside type. The 4 ft. 8½ in. guage is too narrow for cylinders of larger diameter, unless the valve boxes are pushed out of their legitimate place, or the valves are left unbalanced.

The following are the particulars of some new standard engines:

FOUR WHEEL COUPLED LOCOMOTIVE,

built for the Great Southern and Western Railway of Ireland at the Company's works at Inchicore, Dublin, from the designs of Mr. A. M'Donnell, the locomotive superintendent of the line. This engine, although possessing no striking peculiarities, is yet well worthy of attention as a good example of a passenger locomotive for the 5 ft. 3 in. gauge. The engine is simple in construction, and ample bearing surfaces are provided for all working parts; whilst advantage has been taken of the width of the gauge to obtain a good large fire-box. The guide-bars, piston-rods, axles, axle-box guides and axle-boxes are of steel. The principal dimensions of the engine are as follows:

Boiler.	ft.	in.
Diameter of barrel inside smallest plate....	4	0
Length of barrel	9	7
Length of fire-box casing	5	1
Length of inside fire-box at bottom.......	4	6
Width of inside fire-box at bottom........	3	11
Height of inside fire-box at front.........	5	4¼
Height of inside fire-box at back.........	4	8¼
(All dimensions of inside fire-box are inside dimensions.)		
Thickness of barrel and fire-box casing plates	0	0½
Thickness of smoke-box tube plate	0	0¾
Number of tubes 174		
Length of tubes between tube-plates	9	10¼
Diameter of tubes outside tube-plates.....	0	2

Heating Surface.	sq. ft.
Tubes (outside)	887.7
Fire-box	95.45
Total	993.15
Fire-grate area	17.6

Wheels and Axles.	ft.	in.
Diameter of driving wheel................	6	6
Diameter of trailing wheel................	6	0
Diameter of leading wheel................	4	0
Distance between centers of leading and driving wheels	7	0
Distance between centers of driving and trailing wheels	7	9
Total wheel base	14	9
Cylinders.		
Diameter............................	1	4
Stroke..............................	1	10
Distance apart from center to center......	2	6½
Distance apart of frames	4	7

Weight of Engine.			
Empty:	tons.	cwt.	qr.
On leading wheels	9	5	0
On driving wheels	10	4	0
On trailing wheels	9	17	0
Total	29	6	0
In working order:	tons.	cwt.	qr.
On leading wheels	10	5	0
On driving wheels	11	1	0
On trailing wheels	11	1	0
Total	32	7	0

Mr. M'Donnell, we may mention, is now building for his line two double-bogie engines on Mr. Fairlie's plan, these engines having boilers and general details similar to those of the locomotive we illustrate.

SIX COUPLED TANK LOCOMOTIVES,

from the designs of Mr. Samuel Johnson, by Messrs. Ruston, Proctor and Co., of Lincoln, for the Great Eastern Railway. These engines are intended more especially for shunting purposes, for which they are excellently adapted. The cylinders, which are inside, are placed at an inclination of 1 in 10, this being just sufficient to enable the guide-bars to be kept clear of the leading axle. The water is carried in a pair of wing tanks, and the fuel in a coal box at the back of the foot-plate, a cast-iron balance weight being placed beneath the latter to increase the weight on the hind wheels. The leading and driving springs are arranged above the axle-boxes in the ordinary way; but at the trailing end the weight is carried by a transverse spring placed behind the fire-box. In some six-coupled goods engines, with tenders, recently built from Mr. Johnson's designs, a transverse spring is also used at the hind end, whilst the leading and driving springs are connected by compensating beams, so the engines are carried on three points, the transverse spring of course acting as a compensating beam between the two bearings of the trailing axle. In the construction of these engines steel has been largely employed, the horn-blocks, slide-bars, piston-rods, crank-pins and tyres being all of Messrs. Vickers, Sons and Co.'s crucible steel. The barrel of the boiler is made of two plates, butt-jointed above the water line. The principal dimensions of the engines are as follows:

Cylinders.	ft.	in.
Diameter	1	4
Stroke	1	10
Distance apart from center to center	2	4
Length of ports	1	2
Width of exhaust ports	0	3
Width of steam	0	1¼
Width of bars	0	1
Distance from center of driving axle to center of exhaust port	8	10
Working Gear.		
Length of connecting rods between centers,	5	6
Diameter of bearing at large end	0	7
Length of bearing at large end	0	4
Diameter of bearing at small end	0	3
Length of bearing at small end	0	3
Width of guide bars (double)	0	2¾
Length of crosshead blocks	0	9
Diameter of piston rods	0	2¾
Diameter of valve spindles	0	1¾
Distance between centers of valve spindles,	0	4
Boiler.		
Diameter of barrel (inside)	3	9
Length of barrel (inside)	9	1
Length of fire-box casing (outside)	4	4¾
Width of fire-box casing	3	11
Depth at front below center line of boiler,	4	5½
Length of inside fire-box at top	3	8
Length of inside fire-box at bottom	3	9
Width of inside fire-box at bottom	3	4
Height of inside fire-box at front	5	0
Number of tubes 124		
Diameter of tubes (outside)	0	2
Length of tubes between tube-plates	9	4 1/16
Diameter of blast nozzle	0	4¾
	ft.	in.
Diameter of chimney at top	1	3
Diameter of chimney at bottom	1	4
Heating Surface.	sq. ft.	
Fire-box	70.8	
Tubes	608.2	
Total	679.0	
Fire-grate area	12.5	
Tanks.	ft.	in.
Length of side tanks	10	0
Height of side tanks	4	3½
Width of side tanks at widest part	1	6
Contents of tanks .... 778 gallons.		
Length of coal box	2	0
Width of coal box	7	3¾
Wheels and Axles.		
Diameter of wheels	4	0
Distance between centers of leading and driving wheels	6	9
Distance between centers of driving and trailing wheels	6	9
Total wheel base	13	6
Bearings of Driving Axles.		
Length	0	7
Diameter	0	6¾
Distance apart from center to center	3	11½
Diameter of axle between cranks	0	6¾
Bearings of Leading and Trailing Axles.		
Length	0	6¾
Diameter at center	0	6
Diameter at ends	0	7
Distance between centers of bearings of leading axle	3	11
Distance between centers of bearings of trailing axles	3	10
Diameter of leading and trailing axles at centers	0	6
Frames.		
Length inside buffer beams	22	6
Distance apart	4	1
Thickness	0	1⅛
Depth (extreme)	2	7¼
Width over footplate at leading end	7	7
Width over footplate at trailing end	8	4

The weight of these engines is about 35 tons in working order, and they will exert a tractive force, less the internal resistances, of 117.3 lb. for each pound of effective pressure per square inch on the pistons. Thus with a mean effective pressure of 98 lb. per square inch they would exert a tractive force of about 11,500 lb. The boiler is worked at a pressure of 140 lb. per square inch, and is fed by a pair of injectors.

The engines we have described are, as we have said, well adapted for the work for which they are intended; and we understand that their performance has proved exceedingly satisfactory.

STEEL RAILS.

STANDARD PATTERNS ILLUSTRATED.

The sections of rails shown on the opposite page, embrace some of the best patterns, of various weights. The engravings (excepting fig. 3) are half size, and are made accurately to scale. The patterns are as follows :

FIG. 1.—65 *lb. Erie Rail.*—Of this pattern, some 1,000 tons had been made, on a large order, for the Erie road, by Messrs. John A. Griswold & Co., Troy, up to October last, when the converting works were destroyed by fire.

FIG. 2.—56 *lb. Penn. Railroad Pattern.*—This rail was designed by Mr. J. Edgar Thompson, President of the Pennsylvania Railroad, but a heavier pattern (fig. 4) has thus far been adopted on that line. Of the 56 lb. pattern, the Pennsylvania Steel Company have made some thousand tons for various roads—the Pittsburg, Fort Wayne and Chicago ; the Michigan Southern, &c. Messrs. John A. Griswold & Co. have made about the same quantity of the same pattern for the Chicago and Northwestern, Rensselaer and Saratoga, and other lines. This may be called a favorite pattern. It is high enough to be fished to advantage, and well shaped for this purpose.

FIG. 3.—80 *lb. Paris and Lyons Railway.*—This pattern is specially intended for fishing, though we consider the required angle of the fish plate bearing too great; too great a strain would be brought upon the bolts. The rail below it (fig. 5) is much better in this regard. We think a wider head would also be preferable. But the base is very wide—$5\frac{1}{8}$ in., and affords an excellent bearing on the sleepers. The rails are 19 ft. $8\frac{1}{4}$ in. long each. Their ends are unsupported, the distance between the sleepers, between which the joint is situated, being $23\frac{3}{4}$ in. The sleepers next are at a distance of 2 ft. $3\frac{1}{2}$ in., and the others of 2 ft. $7\frac{1}{2}$ in. This gives eight sleepers per rail. The sleepers are made of ordinary, not of hard, sorts of wood. The dimensions of sleepers are : length, 8 ft. 6 in. to 9 ft. 2 in.; breadth, $7\frac{7}{8}$ in. ; height or thickness between, $5\frac{1}{8}$ in. to $6\frac{1}{4}$ in., according to the nature of the wood. On the Northern Railway of France the rails are 5 in. deep, $4\frac{1}{8}$ in. wide at the side, with web $\frac{11}{16}$ in. thick, and they weigh 76 lb. per yard. The Bessemer works at Terre Noire are manufacturing the rails above described for the Lyons Railway.

FIG. 4.—67 *lb. Pennsylvania Railroad Pattern.*—This is the standard pattern on this line, for both steel and iron. Not less than 10,000 tons of steel rails from this pattern, about half of them having been made by the Pennsylvania Steel Company at Harrisburg, are in use. The shape of the head might be slightly improved for fishing, but altogether, it is an excellent pattern.

FIG. 5.—*The 56 lb. "Ashbel Welch" Rail.*—Mr. Ashbel Welch, the President and Engineer of the combined Camden and Amboy and New Jersey Companies, long ago determined to get the maximum service out of the new material. Instead of following the proportions adopted for iron, he made a pattern specially adapted to the greater strength of steel. His first pattern was still thinner in the flange than the present one, and although he expected to meet the views of rail makers a little more closely, in the end, be determined to test the capacity of steel to roll into such thin shapes, and its capacity to stand the service when rolled.—So he told the rail makers that they must make his pattern or none. John Brown & Co. at length undertook it, and found less difficulty than they had expected. The rails were put down where the service was hardest on the Camden and Amboy line, and stood perfectly. But upon the representations of rail makers that such very thin flanges would cost more—there being more "wasters"—and that they would not be as strong in proportion to their metal as thicker ones, on account of their cooling and rolling cold while the rest was hot, Mr. Welch changed the pattern to that shown in fig. 5. This is not a pattern that red short steel, or roughly cast ingots, will roll into with any success, but the Pennsylvania Steel Company have just rolled 500 tons of it for the Philadelphia, Wilmington and Baltimore line, without more than the usual number of bad flanges—in fact, without any difficulty to speak of. This is a very carefully studied and, in an engineering point of view, excellent pattern, but railway companies have thus far selected the other rail of the same weight (fig. 2) in the majority of cases.

FIG. 6.—67 *lb. Erie Steel-headed Rail.*—This is the latest Erie pattern. The Trenton Iron Company are now rolling this pattern, on an order, the extent of which we shall not undertake to mention. They are producing excellent rails with heads made either of puddled steel, or of steel made by the Siemens-Martin process.

Fig. 1.

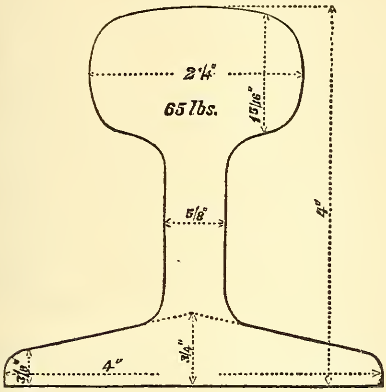


Fig. 2.

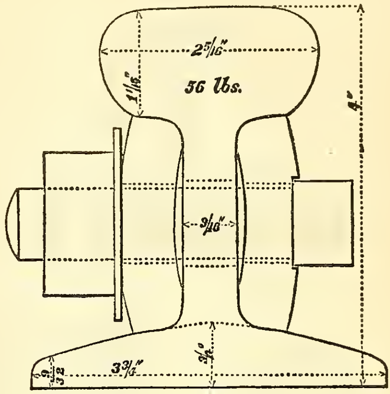


Fig. 3.

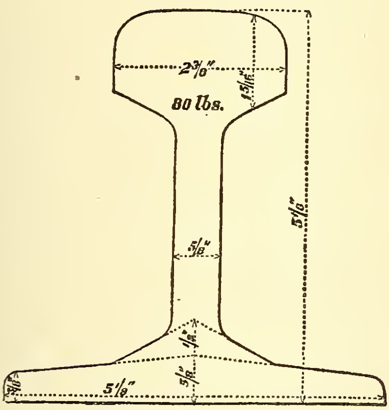


Fig. 4.

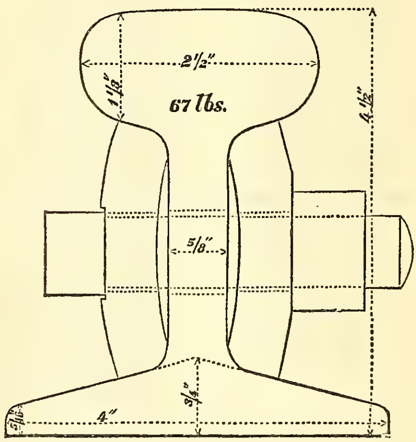


Fig. 5.

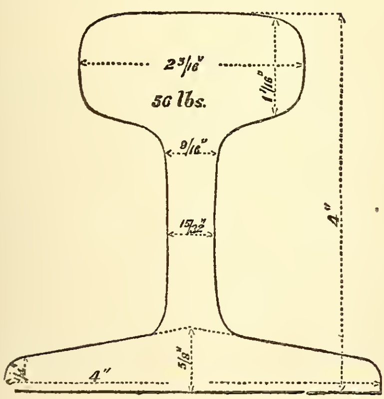
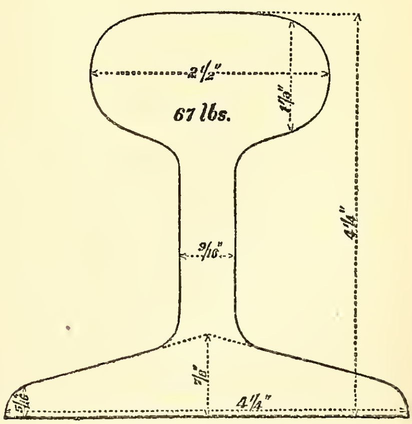


Fig. 6.



REEVES' NEW JOINT FASTENING.

Fig. 1.

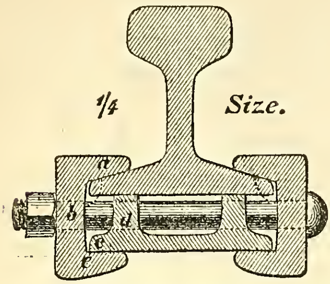


Fig. 2.

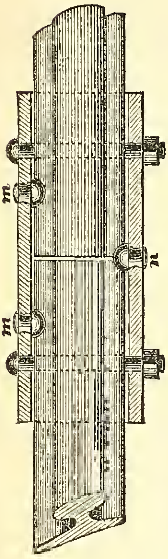
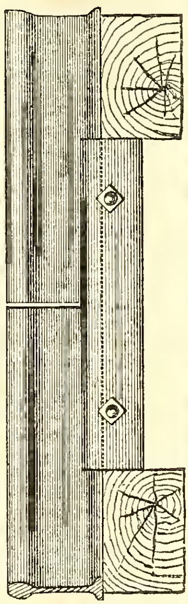


Fig. 3.



The most approved form of this excellent device, to which we have referred on other occasions, is illustrated by the above cuts. It should be explained that stops *n* and *m*, fig. 2, are not used on both sides of the rail. The single stop *n* requiring only the corner of the flange to be cut off, has been heretofore used. Mr. Reeves, however, prefers the two stops *m m*.

The advantages of this joint fastening, especially for steel rails, are very clearly set forth by the letter of Mr. Hinckley, President of the Philadelphia, Wilmington and Baltimore Railway (see page 357). The engineer of this line reports that only two nuts in the 8,000 in use have been found loose, and that only one clamp has been broken, and this by driving it with a sledge upon the rail. The motion of a train over these joints is noticed to be very smooth, and instead of the clatter observable in case of a common chair, or any loose joint, a peculiar ringing noise is heard, resembling the sound of a solid piece of metal when struck. This is the best evidence of the continuity produced by a tight joint.

The elasticity of the joint is another noticeable feature. There is nothing about it representing an anvil. The points *a*, *c*, *e*, and also the edge of the flange, may all yield very slightly. That they do so yield is proved by the fact that no wear is observed between the parts in contact. Wear always occurs between rigid parts similarly situated, as in case of the old-fashioned compound rails.

The weight of this fastening complete, with clamps 14 in. long, is 30 lbs. Its cost is $2.

The Rensselaer Polytechnic Institute—This scientific school is one of oldest, if not itself the oldest, in the country; and certainly no other American institution has furnished so many successful engineers. The course of study is very severe; and young men who graduate and receive their degrees at Troy are qualified to commence brilliant and useful careers.

It seems strange to us that for so many years, during which other institutions, no whit more deserving of support, have been munificently endowed, this one has been left entirely dependent upon the fees of the students. As a consequence those rates are comparatively high. Two hundred dollars a year is, we are informed, the present charge for tuition; and it is not found to be more than sufficient for the maintenance of an efficient system of instruction and practical training. But it undoubtedly operates to prevent many from attendance who would gladly purchase, at a lower rate, the benefits of a scientific education.

In addition to its age and general excellence, the Rensselaer Institute has two special claims upon the public. The first lies in the fact that in the destruction of its buildings by fire, a few years ago, its scientific resources were sadly crippled. It is true that indomitable energy and perseverance have done much to repair the damage. A new and handsome building upon the steep hill-side overlooking the city of Troy, and the beautiful and well-appointed Winslow laboratory close by, bear witness to the vitality which inheres in this enterprise, and give promise of its extended activity and influence in the future. The Institute is gradually replacing its lost library, apparatus and collections. It is slowly recovering from the disaster which befell it; and there is no doubt of its ultimate and complete success on a larger scale and by a higher standard than measured its ancient glory. But this recovery, however sure, ought to be quick, not slow. Whatever money can do to annihilate time should be done.

The other claim of this institution upon the public is the provision which has been made in its courses for the education of mining engineers and metallurgists. During a recent visit we were much pleased with the progress already achieved in this department, and the judicious plans matured for the future. As our readers are aware, Prof. G. W. Maynard occupies the chair of mining and metallurgy.

When it shall at last come to pass that our American, like the European mining schools, shall be distinguished, each in some special branch of the arts related to mining, we think Rensselaer will be likely to represent especially the metallurgy of iron, a branch so important as to form in some foreign schools, as, for instance, that of Losben, the chief attraction for students, and the main portion of the instruction imparted.

Troy is the site of the far-famed Burden iron furnaces and rolling mill, as well as the scarcely less celebrated Bessemer Steel Works of Messrs. John A. Griswold & Co. The latter were seriously injured—we may almost say destroyed—by fire a few months ago, but are now being rebuilt under experienced management. They can produce at present but eight tons of Bessemer steel daily; but the works now in progress will increase this capacity to upwards of fifty tons. The innumerable puddling furnaces and other iron-metallurgical works in Troy, added to the two establishments we have mentioned, are so many arguments for the importance of maintaining with ample power, in the midst of an industry so vast and profitable, an institution like the Rensselaer, to serve as a storehouse for the preservation and an exchange for the communication of a great number of valuable observations concerning the latest processes of the metallurgy of iron. Moreover some provision might be made for giving certain courses of instruction by public lectures or otherwise to the workmen themselves. Even a common laborer accomplishes all the more and all the better for understanding what he is doing.

A course of popular and scientific lectures is in progress for the aid of the Institute library. We sincerely hope it may succeed; but this is too slow a means to achieve the desired result. There is little merit in urging other men to give their money for the public good; but we think ourselves justified by the circumstances in remarking that the rich men of Troy, and all the graduates of the institution, or their friends, should unite to raise for the school a large permanent endowment. Such assistance, rendered at the right moment, *i. e.*, very soon, would have a marvelous effect in stimulating the activity and doubling the beneficent influence of the Institute. Who endows the Rensselaer school?—*American Journal of Mining.*

ENGLISH ORDNANCE EXPERIMENTS.

EFFECT OF CANNONADING A CASEMATE, UPON SHELLS STORED WITHIN IT.

From "Engineering."

On February 11th, an experiment was conducted at Shoeburyness, with the view of ascertaining the probable effect which would be produced by a cannonade upon a casemate within which loaded shells were stored, and also the extent of damage which the explosion of one shell would produce upon the surrounding ones. For this purpose 50 live common shells, for the nine in. rifled gun, were disposed with the area of an armor-plated casemate. Each of these shells contained a bursting charge of eighteen lb., in all 900 lb. of powder. The floor of the casemate is about 20 square feet, the height to the crown of the brick-turned roof being about twelve ft. The opening at the west end of the casemate was closed up by two seven in. thick iron plates, eight ft. six in. by four superficial, and weighing about five tons each. The opening at the east end was closed by several large sheets of iron $\frac{3}{4}$ in. skin and the huge rope manlet. The rears of the two casemates were left perfectly open. The main mass of the shells, 42 in number, and containing 798 lb. of powder, were laid on their sides, and piled in two rows, with their plugged ends pointing laterally outwards. For the convenience of aiming the gun through the porthole, the pile of shells was raised two ft. nine in. above the floor on a platform about eight square feet, composed of bags of sand and concrete, packing-boxes, and loose earth, covered over with an old deal target. Four shells were placed against each wall of the casemate at the side, about six ft. or seven ft. away from the pile.

The nine in. Woolwich muzzle-loading rifled gun was placed at 70 yards in front of the casemate, and laid at the center of the pile, as seen through the open port. The charge was the full battering charge of 43 lb. of large grained rifle powder, and the Palliser shell weighed, empty, 246 lb., and contained a bursting charge of five lb. twelve oz. The gun was fired by the magneto-electric apparatus, and the result of the explosion on the exterior of the casemate was to shake the massive brickwork and masonry of the casemate, to widen and increase the cracks and fissures made by the former firing against the armor, and to open new ones. Inside the structure the wreck was terrible to look at, the whole floor of the casemate being covered with the *debris* of concrete, earth, fallen bricks, fragments of wood, and exploded shells, commingled with entire shells which had not been injured, and which were thrown about in all directions, one 28 yards away on the open beach to the rear. On closer examination it was found that nineteen shells had been exploded, and that 31 had been hurled violently away without damage. Fearful, therefore, as the destruction looked, it must be remembered that the experiment was a thoroughly crucial one, and that the shells had really shown themselves as safe magazines for powder as could possibly be expected.

In the interior of the casemate itself there was first the concrete and earth platform; the floor was covered to the depth of some inches with the *debris*. Two shells lay close to the front, one on each side of the port; another on the sill of the west opening, the four which were stood erect along the rear part of the west wall being all blown aslant, and two others out of the pile lying aslant likewise, close to the wall beside them. The large iron skin (6 ft. 6 in. by 6ft. 6 in., $3\frac{3}{4}$ in.) at the back of the shield buttress, was blown down.

To the seaward, within seven ft. of the casemate, there were ten unexploded shells, one had a fragment broken from its rear end six in. in length and one in. wide. Sixteen feet seaward of this again, lay two whole shells on the west side, and at fourteen ft. one on the east side; and still farther seaward, 28 yards away from the casemate, lay the most distant of the shells cast away from the pile by the explosion. Thence to the water's edge, some 70 paces, the ground was strewed with fragments of shells and broken wood. Outside the eastern opening the two seven in. plates were blown away from six to twelve ft., two whole shells were lying among the *debris* of sand bags; 30 ft. from the casemate a third whole shell was found perfectly uninjured.

The front of the pile of shells before the firing was 21 ft. from the face of the port-hole; the quantity of powder in the shells exploded was 342 lb. The attacking shell would seem to have driven right through the two lowest tiers of piled shells, say twelve and ten respectively, and, in total, 22, exploding nineteen, and knocking the three rear ones away.

PRACTICAL INSTRUCTION IN ENGINEERING.—The engineering course at Lafayette College has some features which are worthy of the attention of all our technical schools. While the general curriculum, embracing four years, is designed to give the engineer all the culture of a thorough college course in addition to the special instruction for his profession, this class is organized as an engineering corps, and goes through all the necessary operations for the construction of a railroad from Easton to some selected terminus. This work includes reconnoissance, running preliminary lines, fixing the final location of the road with the most favorable attainable grades and curves, the construction of maps, profiles, cross sections, &c., the computation of excavation, masonry, &c. The field work and office work, including drafting and calculation, are performed under the immediate direction of Professor Walling, who accompanies the corps and directs their investigations. The bridges, tunnels and depots, are also located, and all necessary plans and calculations are made, with a discussion of the principles involved. In short, the whole work of a division engineer is performed, so that the graduate has not only scientific theory, but actual practice, and is ready at once to assume important and responsible positions.

We may add that the technical courses at Lafayette have all been recently enlarged and greatly improved. Mr. Pardee, of Hazleton, Pa., has contributed for this object the munificent sum of two hundred thousand dollars, making, with the generous donations of other friends of the institution, nearly half a million of dollars lately added to the college funds.

PAPERS ON CONSTRUCTION.
No. I.

By Lieut. C. E. Dutton.

The determination of the strength of materials involves an investigation into the following conditions: (1) the nature of the material; (2) the stress to which the various pieces are subject; (3) their shapes and dimensions; (4) the manner of their support. Although other conditions must be frequently considered, the foregoing are universal.

It is not proposed, in these papers, to discuss the more general properties of material separately, since these are in the main well understood. Particular discussions, however, in connection with other conditions will be given in the proper places.

The strains to which material is subjected may be reduced to five kinds: (1) tension, (2) compression, (3) transverse strain, (4) shearing, (5) torsion. To these might be added a sixth, viz; those internal strains resulting from the peculiar molecular constitution of the material when subject to certain forces acting upon molecules or atoms. This kind of strain, however, should more properly be considered in a discussion of the nature of materials.

1. A body is subject to a strain of *tension* when two forces are acting upon it in opposite directions, and *from* each other. A body fixed at one end, and having a tensile force applied to the other, resists rupture by the cohesive force inherent in the molecules which constitute it. It is generally assumed that, in a body nearly homogeneous, each molecule opposes to a given force a resistance nearly equal to that of every other molecule. Although this assumption is only approximately true, it is necessary to make it, since it is the only way in which we reduce the phenomena of resistance of materials to system, and subject them to analysis.

It will be safe enough to assume, whatever may be the resistance of any molecule to rupture by a given force, that their average resistance is a constant quantity. On this assumption the total resistance of a body to rupture by tension, at a given section, will be the sum of the resistances of all the molecules of that section. The number of these is directly proportional to the area of that section, and hence the resistance will always be proportional to that area.

This proposition must be qualified in particular cases by the condition that the stress be applied equally, and at the same time, to every portion of that area. In the case of a cylindrical rod, or bar, if the force be applied at the convex surface of the cylinder only, it is evident that a portion of the surface will be strained more than the central or axial portions, and the cylinder will yield to a force less than that due to the area of section, by the rupture, first, of the surface portions, and then of portions successively nearer the axis.

2. All materials under tension are elongated. The elongation becomes permanent when the tension is great, and increases in a higher ratio than the force applied. A restoration takes place when the force is removed; but it is only partial, except in cases where the force is slight compared with the ultimate strength of the material. Continuous tension, or tension repeatedly applied, even within the limits of elasticity, will produce a set, and if sufficiently continued will ultimately produce rupture, or seriously impair the strength. A slight diminution takes place in the permanent set when the body is allowed a protracted rest. Within the limits of tension to which sound practice would subject any material, it will give a closely approximate result if we make the extension proportionate to the force applied. It is also in direct ratio to the length of the piece, and in an inverse ratio to the area of section; whence the following formula: $e = \frac{t\,l}{A}m$, in which $e =$ the extension, $t =$ the strain, $l =$ the length of a piece of uniform section, $A =$ the area of that section, and $m =$ a co-efficient to be determined by experiment.

In most equations relating to the strength of materials, experimental co-efficients necessarily enter. These co-efficients are dependent for their value upon the properties of the materials under discussion, as determined by direct experiment. Thus, in an expression of the tensile strength or resistance to compression, it would indicate the tenacity or resistance per square inch: in an equation of transverse strength it may express the transverse strength of a piece of material one foot long and one inch deep. In general it may be said to express the value or amount of a particular property, found experimentally in a piece of the material under discussion having given dimensions.

For a moderate stress of tension the elongation of a bar is approximately a measure of the strain. The *modulus* of *elasticity* for extension (which is a method of expressing the resistance to extension) is determined by the amount which a bar of given size can be extended by a given weight. This resistance will evidently vary directly as the length and stress, and inversely as the extension. Let l be the length, s the stress, and e the extension; then $M=\frac{l\,s}{e}$. This expresses merely the intensity of resistance within the limit of elasticity, and does not hold good beyond it.

3. In practice it is found necessary to divide the theoretical strength of all materials by a divisor varying with the material and kind of strain, for the working strength of all materials intended for continued use is seriously affected by various causes which cannot be calculated, except as average results of experience. In tensile strains the safe load is usually estimated at from one-tenth to one-fifth the theoretical strain. The divisor is called the "*factor of safety*. Since all estimates for strains, of whatever kind, require modification by a suitable factor of safety, the relations of "breaking loads," "proof loads," and "working loads," to each other will be specially treated of hereafter.

4. *Resistance to crushing.*—Crushing is an operation of considerable complexity. In practice materials seldom yield to direct compression. It is only when pillars of considerable length are subjected to such a stress that rupture occurs, and then it is produced by flexure, and almost never by a collapse of the material itself. The strength of a column, therefore, will depend both upon its resistance to crushing and its rigidity. Mr. E. Hodgkinson, of Manchester, has investigated this subject experimentally with great ability, and his results have become standard among engineers.

Rupture by compression may take place in the following modes: (1) by splitting into laminated or prismatic fragments, like hard wood well seasoned; (2) by bulging, lateral swelling, or spreading, which is characteristic of tough, ductile material like wrought iron. In both these cases the resistance is decidedly less than the tenacity, and takes place gradually. (3) By sliding, or oblique shearing, which occurs in substances of a granular or crystalline texture like cast iron and stone. In such cases wedges or cones are forced out laterally. (4) By buckling, which takes place in beams made of flexible material, and longer than those which yield by bulging.

The formulæ obtained by Mr. Hodgkinson are as follows:

Let $D=$ the external diameter or side of square in inches.
Let $d=$ the interior diameter of hollow column in inches.
Let $l=$ the length in feet.
Let $w=$ the breaking weight in tons (2000 lbs.)

Solid cylindrical column cast iron, ... } $w=49.4\frac{D^{3.55}}{l^{1.7}}$

Hollow cylindrical column cast iron, . . } $w=49.6\frac{D^{3.55}d^{3.55}}{l^{1.7}}$

Solid cylindrical column wrought iron, . . . } $w=149.7\frac{D^{3.55}}{l^{2}}$

Solid square pillar of oak, ... } $w=12.2\frac{D^{4}}{l^{2}}$

The foregoing formulæ are for columns with flat ends whose lengths are from 30 to 60 times their diameters, and which yield wholly by bending. When the columns are shorter than these proportions, and are longer than five or six times their diameter, the rule is as follows: first, find the value of w by one of the preceding formulæ; then let $c=$ the crushing strength per square inch of the material under discussion, then breaking weight $=\frac{c}{1+.75\frac{c}{w}}$.

The following formula is deduced by Mr. Lewis Gordon from Hodgkinson's experiments for a column of *any* section.

Let $w=$ breaking weight in lbs., $a=$ sectional area in inches, $l=$ length, $d=$ the least external diameter, $c=$ a constant dependent upon the crushing strength per sq. in. of the material, $e=$ a constant dependent upon resistance to flexure; then, approximately, $w=\frac{c\,a}{1+e\left(\frac{l}{d}\right)^2}$.

The following are the values of c and e for iron pillars having flat ends:

	Values of e.
Wrought iron.	$\frac{1}{3000}$
Cast iron.	$\frac{1}{400}$

Values of c.	Breaking load.	Proof load.	Working load.
Wrought iron.	36,000	18,000	6,000 to 9,000
Cast iron.	80,000	26,700	13,300 to 20,000

In using the foregoing formula it will be necessary to use care in determining the ratio $\frac{l}{d}$. In wrought iron frame-work and machinery the bars which act as struts, in order that they may have sufficient stiffness, are made of various forms in cross section, well known as "angle iron," "channel iron," "T-iron," and "double T-iron," etc. In each of these forms the line to be considered as d is the diameter in that direction in which the bar is most flexible, of a triangle or rectangle circumscribed about its section.

The ultimate resistance of wrought iron tubes, composed of plate iron riveted to angle irons at the corners, was stated by Mr. Fairbains to be 27,000 lbs. per square inch of section of iron. This is in cases where the ratio of length to diameter exceeds 30. The yielding is always by buckling. But when a number of these tubes are placed side by side, the resistance becomes 33,000 or 36,000 lbs. The same co-efficients apply also to cylindrical tubes. (Rankine.)

5. In cases where the center of pressure does not coincide with the axis of the column, it is evident that a greater strain will be thrown on one side than on the other, and the load which the column will sustain will therefore be diminished in the ratio in which the mean intensity of the stress is less than the maximum intensity. To find that ratio it is sufficiently near the truth to assume that the stress is uniformly varying.

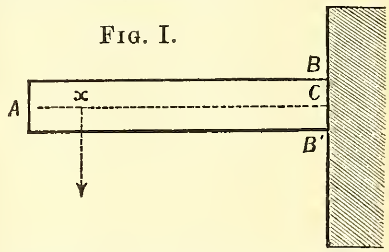
Let $x =$ the greatest deviation of the center of pressure from the center of figure in any cross section; that is, the greatest deviation of the line of action of the load from the axis of the pillar. Let x' be the distance of the point of greatest stress from the axis of the pillar; that is, the same diameter of the pillar in the direction in which the load deviates from the axis.

Let I denote what is called the moment of inertia of the cross section of the pillar (a term which will be explained under the head of transverse strength); let $S =$ the area of the transverse section in sq. inches, and let $f =$ the resistance of the material to crushing in lbs. on the sq. inch. Then the crushing load is $P = \dfrac{f\,S}{1 + \dfrac{xx'S}{I}}$. The following are some of the values of $\frac{x'S}{I}$ in this formula. (Rankine.)

I. Rectangle $h\,b$; b neutral axis, ...	$\frac{6}{h}$
II. Square h^2	$\frac{6}{h}$
III. Ellipse; neutral axis b; other axis h, . . .	$\frac{8}{h}$
IV. Circle; diameter h, .	$\frac{8}{h}$
V. Hollow rectangle outside diameter $h\,b$; inside diam. $h'\,b'$; neutral axis b, ...	$\frac{6\,h\,(h\,b - h'b')}{h^3\,b - h'^3\,b'}$
VI. Hollow square $h^2 - h'^2$	$\frac{6\,h}{h^2 + h'^2}$
VII. Circular ring diameters h and h', . . .	$\frac{8\,h}{h^2 + h'^2}$

6. *Transverse Strength.*—A horizontal beam having one end fixed in a vertical wall, and subjected to stress in a direction perpendicular to its length, will be forced out of its normal shape and subjected to internal strains of a complex nature. If a weight act vertically downwards, the upper layers of the beam will be subjected to tension, and the lower layers to compression. There will be an intermediate layer where neither of these forces operates, and this is called the "*Neutral Axis.*"

Fig. I.



It is plain that the greatest tension occurs at the upper surface, and the greatest compression at the lower surface, and the amount of change in any layer is proportional to the distance of that layer from the neutral axis. The effect produced upon the beam by a given weight will obviously vary directly as the distance from the wall at which it is applied. If $A\,C$, Fig. I, be the neutral axis, then $A\,C\,B$ and $A\,C\,B'$ may be regarded as bent levers of which the arms $C\,B$ and $C\,B'$ are constant; and if the weight W be applied at the distance x, then the effect of W will vary as x. If W be multiplied by the distance at which it acts, the product will be what is called the "*Moment of the Weight;*" *i. e.*, the amount and efficiency of the force as determined by its "*leverage.*" When the weight is applied at a single point, then the moment of weight

$= Wx$. When it is distributed over a continuous length, it is plain that each point has a moment of its own, and that the whole moment will be equal to the sum of the moments of all the parts. Suppose the beam to be divided up into an indefinite number of equal parts, having the length dx; then the weight on each of these parts will be proportional to the length of the part, and equal to the intensity of the weight multiplied by this length. The intensity of weight for a unit of length is equal to the whole weight divided by the whole distance over which it is distributed, and in case the beam is uniformly loaded over its whole length, the intensity will be $\frac{W}{l}$ and the weight upon $dx = \frac{W\,dx}{l}$. The moment of this weight will be $\frac{W}{l}.x\,dx$, in which expression $\frac{W}{l}$ is a constant quantity. The entire moment therefore (making $x = l$) is

$$M=\frac{W}{l}\int x\,dx=\frac{W}{2\,l}\cdot\frac{1}{2}x^2=\frac{W^3 l}{2}.$$

The moment of a uniformly distributed load is therefore one-half the moment of the same load acting at the free end. In case the load is uniformly distributed over a part of the length $= a$ between the points x and x', the above expression becomes

$$M=\frac{W}{a}\int_{x'}^{x} x\,dx=\frac{W}{a}\tfrac{1}{2}\left(x^2-x'^2\right).$$

Making $x = l$ and $x' = l-a$ the above becomes

$$M=\frac{W}{a}\tfrac{1}{2}\left(l^2-(l-a)^2\right)=W\left(l-\frac{a}{2}\right).$$

7. When a beam is supported at both ends, and a weight applied between the supports, we may consider the reaction of these supports as forces acting upwards upon the free ends of a beam supported in the middle; or the beam may be considered as a lever of the third order, where the power is applied between the extremities. Adopting for the present the latter view, and making $l =$ the distance between supports, and $x =$ the distance from A of the point of application of the weight, then the pressure upon B, or what is the same thing, the reaction of B will be inversely as the length, and

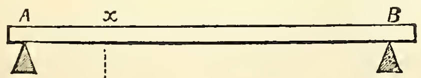


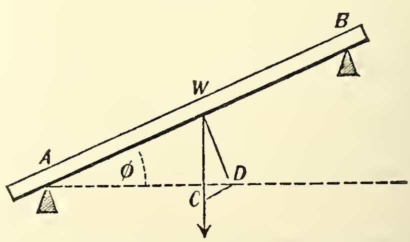
Fig. II.

directly as the weight, and the distance from A; *i. e.*, $P=\frac{Wx}{l}$. Similarly, the pressure upon A will be inversely as the length, and directly as the weight, and the distance from B; *i.e.*, $P'=\frac{W(l-x)}{l}$. Adding these equations $P+P'=\frac{Wx}{l}+\frac{W(l-x)}{l}=W$, we find that the sum of the pressures upon the two supports is equal to the whole weight. The moment of reaction of the support B will be $=P(x-l)=\frac{Wx\,(l-x)}{l}$ and the moment of reaction of the support A also $=P'x=\frac{W(l-x)\,x}{l}$: therefore these two moments are always equal. Since, in every case $x+(l-x)=l$, the equation of moment becomes a maximum when $x=\frac{l}{2}$, and becomes zero when $x=o$, or $x=l$. Hence the moments of weight are greatest when the weight is in the middle of the beam, and are nothing when it is at either support. Making $x=\frac{l}{2}$, then $\frac{Wx\,(l-x)}{l}=\frac{1}{4}\,W\,l$, *i. e.*, the effect of a weight placed in the middle of a beam supported at both ends is one-fourth the effect of the same weight at the free end of a beam fixed at one end.

In the case of a uniformly distributed load we may assume the supports to be forces acting upwards against a beam supported at the center by the weight. By referring to equation (1) it will be seen (bearing in mind that $x=\frac{1}{2}\,l$) that $M=\frac{1}{2}P\,(l-x)$ $=\frac{\frac{1}{2}\,Wx\,(l-x)}{l}=\frac{1}{8}\,Wl$. Hence, a beam will support twice as great a load distributed uniformly as it will when the load acts at the center alone.

8. When the weight does not act perpendicularly to the length of the beam, the foregoing conditions are somewhat modified.

Fig. III.

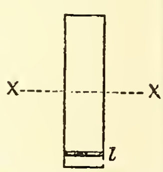


Let $A\,B$ represent a beam—its axis making with the horizon an angle $=\phi$. Let the weight act vertically, and let $W C$ represent the magnitude of the weight. Resolve $W C$ into two components, $W D$ and $D C$; the former perpendicular and the latter parallel to the axis of the beam. Then $D C$ is a force having no transverse effect, but is subject to the laws of longitudinal stress, while the component $W D$ represents the whole of the transverse effect of W. The relation of $W D$ to the whole load is expressed by the equation $W D = W \cos. \phi$, and the equation of moment becomes $M = \frac{W x (l-x) \cos. \phi}{l}$.

9. From the foregoing, therefore, we may deduce *the general principle, applicable to all cases of transverse strain, that the effect of a load upon a beam varies directly as the length of the beam.* It now remains to determine the relations of the load to the cross section. Reverting to Fig. I, it is apparent, assuming that $A\ C\ B$ and $A\ C\ B'$ are bent levers, that the intensity or effect of the resistance of any layer to extension or compression must vary as its distance from the neutral axis, because the leverage is proportional to that distance. But owing to the curvature of the beam the tendency to rupture or the strain is also directly proportional to that distance. These two forces are always equal and in opposition, up to the limit of elasticity either for compression or extension, and therefore hold the beam in stable equilibrium. Beyond that limit the action of these forces follows no known law. Our discussion, therefore, must be with reference to strains within that limit.

Let Fig. III represent the cross section of a rectangular beam, of which XX' is the neutral axis. Let l be any layer of very small thickness at the distance x from the neutral axis. Let t be the thickness of the layer, and s the intensity of the stress to which it is subjected. Let b = the breadth of the beam. Since the intensity of the stress varies directly as its distance from the neutral axis, then $\frac{s}{x} = c$, a constant quantity. The amount of stress on the layer l will be expressed thus: $Q = s\ b\ t = c\ x\ b\ t$. If we assume l to be at the edge or surface of the beam, and divide the distance between it and the neutral axis into an indefinite number of layers of the thickness t, then the amount of stress on each layer may be expressed in the same way as that on l.

Fig. III.



Thus the amount of stress on the layer next to l will be $Q' = s'\ b\ t$, and on the next, $Q'' = s''\ b\ t$. The moments of these stresses, *i. e.*, the amounts multiplied by the distances from the neutral axis, will be $s\ b\ t\ x$, $s'\ b\ t\ (x-t)$, $s''\ b\ t\ (x-2)$, etc., and their sum will be equal to the moment of resistance of the entire portion of section under discussion.

$$R = b\,t\{s\,x + s'(x-1) + s''(x-2) + s'''(x-3) \ldots\ldots\ldots + s^n\,(x-n)\}.$$

Now, $s = c\,x$, $s' = c(x-t)$, $s'' = c(x-2'')$ etc., and $t = \frac{x}{n}$ substituting these values in the foregoing equation

$$R = c\,b\,\frac{x}{n}\left\{x^2 + \left(x - \frac{x}{n}\right)^2 + \left(x - \frac{2\,x}{n}\right)^2 + \left(x - \frac{3\,x}{n}\right)^2 \ldots\ldots\ldots + \left(x - \frac{n\,x}{n}\right)^2\right\} =$$

$$c\,b\frac{x^3}{n}\left\{1 + \left(\frac{n-1}{n}\right)^2 + \left(\frac{n-2}{n}\right)^2 + \left(\frac{n-3}{n}\right)^2 \ldots\ldots\ldots + \left(\frac{n-n}{n}\right)^2\right\}.$$

The sum of the series contained in the brackets $= \frac{n}{3}$ therefore $R = c\,b\frac{x^3}{n} \times \frac{n}{3} = \frac{1}{3}\,c\ b\ x^3$.

Substituting for c its value $= \frac{s}{x}$

$$R = \frac{s}{x} \times \frac{b\,x^3}{3} = \tfrac{1}{3}\,s\,b\,x^2. \qquad (1)$$

Hence the resistance of a beam varies as the square of the depth.

The same result is obtained by direct integration, thus: making $t = dx$, then the moment of stress upon the differential layer $l = \ s\ b\ x\ d\ x = \frac{s}{x'} b\,x^2\,d\,x$. Then, since $\frac{s}{x'}$ is a constant, the whole moment of resistance becomes $= \frac{s}{x'}\int_o^{x'} b\,x^2\,d\,x = \frac{s}{x'} \times \frac{1}{3}\,b\,x^3$. Making $x' = x$ we have the same result as before.

The factor $\frac{1}{3}\,b\,x^3$ is termed the "moment of inertia" of the cross section. It is compounded of three factors, expressing as many relations: first, the intensity of resistance made by any particle of the section to a stress, which intensity varies directly as the distance from the neutral axis; second, the area, $b\ x$ of the section, or the number of particles which resist, and third, the distance or moment proper from the neutral axis at which the force acts. The factor s is termed the *modulus of rupture*, of working load, or of proof load, according as the one or other of these stresses is in question. Its value must be determined experimentally in beams of each kind of material, and in general does not correspond exactly either to the modulus of rupture for tension or for compression, but has a special value peculiar to transverse stresses.

The foregoing applies to beams of rectangular section; for beams of any other form the expression must be correspondingly modified. The analysis given has been with respect to one side of the neutral axis. An equal amount of resistance of an opposite kind takes place on the other side. So long as s does not exceed the limit of elasticity, either for the compression or extension of the material, the moments on both sides the neutral axis will be equal, and we may assume that this axis passes through the center of gravity of the section. In the rectangular section, making $d = 2x$ the depth of the beam, and substituting, we have $R = \frac{s}{3x} . b x^3 = \frac{1}{6} s b d^2$, and the moment of inertia becomes $\frac{1}{12} b d^3$.

10. In deducing from the foregoing the resistance of a beam having some other section, let $m =$ a factor depending upon the form of that section. Then the equation of resistance becomes $R = \frac{1}{6} m s b d^2$. The following table gives the values of m for several forms.

Form of Section.	$m =$
Circle $D =$ diam........	$\frac{6}{32}\pi = 0.5892$
Ellipse	the same.
Hollow rectangle $b d - b' d'$	$1 - \frac{b' d'^3}{b d^3}$
Hollow circle...........	$\frac{6}{32}\pi \left(1 - \frac{d'^4}{d^4}\right)$
Hollow ellipse..........	$\frac{6}{32}\pi \left(1 - \frac{b' d'^3}{b d^3}\right)$
Isosceles triangle base $= d$...	$\frac{1}{4}$
I section where $b' =$ sum of the depths of channels..	same as hollow rectangle

11. Hence we draw the conclusion that the transverse resistance of a beam varies as the square of the depth. Having shown already that the resistance varies inversely as the length, it remains to consider the effect of the breadth. It is plain that if we divide a beam by a vertical plane parallel to the axis, the strength will be in no wise affected; the combined resistance of the sections being equal to that of the undivided beam. Therefore the beam will vary as the number of elementary sections into which we may conceive it to be divided, or, in other words, will vary directly as its breadth.

12. The strength also will be modified by the kind of material and its properties with reference particularly to its resistance to direct tension or crushing. If the resistance of the material to tension is greater than to compression, it will yield transversely by the buckling or collapse of the compressed surface. This is the case with wrought iron or wood. If the resistance to direct compression is greater, the yielding will be by the rupture of the extended or convex surface. In computing the effect, therefore, of the peculiar nature of any material, it will be necessary to ascertain, first, whether its tensile or compressive strength is the greater, and to assume the less of the two as the true strength. Knowing the modulus of rupture for direct tension and compression, we would be able to compute readily a theoretical transverse strength of a beam of given dimensions and material. Practically, however, such a computation would be in many cases valueless, because no material is perfectly homogeneous and free from internal strains, which are beyond the reach of mathematical investigation. A lack of homogeneity may not interfere with tolerably uniform results in experiments made upon the tensile strength of materials, because such defects are generally averaged throughout a mass, and the strain at every point is uniform. But the tension developed by a transverse stress is not uniform, but varies as its distance from the neutral axis, and a want of homogeneity in the extreme outer layer is sure to make itself apparent by yielding at the point where it is weakest. The use, therefore, of the constants which would be furnished by the moduli of elasticity is inadmissible. A much more reliable method, as already intimated, is to determine the resistance of beams of standard size to transverse stress for each kind of material, and adopt the results as co-efficients.

Nor is this the only error to which such a computation would be liable. It is found in practice that the value of a constant depending upon the nature of the material, is constant only for a given form of cross section. The same material, in beams of different cross sections, will offer an amount of resistance which cannot be accounted for by the known relations of form to theoretical strength. It becomes necessary then to determine experimentally the value of each kind of material in beams of various cross sections before we can obtain an empirical constant which is to be depended on. Any other method of arriving at such values is always liable to a very material error.

Representing by m the value of this experimental constant, and having already determined the relations of the three dimensions—length, breadth and depth—we may now proceed to deduce general expressions for the relations of the load to the dimensions of the beam, within the limits of elasticity. In all cases the resistance, R must be equal to the tendency to rupture, N; and the expression

$$N = R$$

must be true for all possible values and conditions. But it has already been shown that the stress or tendency to rupture is equal to the moment of the weight $N = Wx = Wnl$ (n being a constant dependent upon the position and distribution of the load), and the resistance is a compound of the breadth, the square of the depth, and the experimental constant m, $R = m\,b\,d^2$. Hence

$$W n l = m\,b\,d^1.$$

Excellent tables, from which the values of m may be deduced will be found in the "Engineers' and Mechanics' Pocket Book," by Charles H. Haswell, Esq.

(To be continued.)

IMPROVED WORKING OF STONE QUARRIES.

By M. Camille Trougnoy. Translated from "Annales du Génie Civil" for "The Engineer."

We saw some months ago a granite quarry worked, at Beauvais-les-Rochers (for paving stone) with a powerful machine, invented by M. Joanne Ronceroy, which completely supplants powder and yet allows of the granite being detached in blocks and broken up almost without waste. The principal part of this machine is a monkey (drop) of 800 kilogrammes, carried with two iron rods which guide it in its fall, on a carriage which turns on the arm of a crane. This arm is horizontal, its jib is 12.50 metres in length, and about eight meters above the ground level. It is the fall of the monkey which detaches the blocks. A chain worked by a windlass raises the monkey when it has fallen, and nippers detach it when raised. The monkey is a mass of cast iron with two ears placed laterally on it, through which pass the guiding rods, and two more on the upper part by means of which the rope is fastened which, with the assistance of a pulley, serves to hang it on the raising chain carrying the nippers. The monkey is pierced by a hole opening into a cavity which receives a mass of iron (a die) on the lower surface of the monkey and which gives the blows. The object of the hole is to enable the die to be removed when worn. The guiding rods are round bars of iron twelve to fourteen meters long and six to eight centimeters diameter. They are kept at the same distance apart by a plate on the turning carriage, which has two holes bored in it of greater diameter than the rods. The lower part of the rods is fastened and kept at a fixed distance apart by a short iron strap, carrying two wooden blocks which can oscillate in the strap. Between the two blocks is left a free space through which the monkey can pass. The blocks of wood serve to deaden the shock after the blow has been struck on the stone to be detached. Finally, at each end the strap is provided with two pulleys, on which run two chains to raise and lower the rods at will. These chains work on a second windlass, independent of the one which belongs to the monkey. The carriage is like that used for the cranes of stores, and is worked by a chain from a third windlass. The arm of the crane is formed by joining two beams in the shape of a double T made of sheet and and T-iron, between which rolls the carriage. The complete machine carries three arms identically the same and symmetrically placed. The vertical shaft is borne on a large truck moving on rails, the surface of which is a square of five meters. On this platform is placed a horse-gin, to which the vertical axis serves as an axis of rotation. The horse-gin is hidden by vertical sides forming an enclosure, in which moves the horse which works the horse-gin. By means of a lever the different windlasses can be placed in connection with the horse-gin. Besides, the dispositions are such as that it is possible to give a rotary motion to the vertical axis to which the arms are attached, without displacing the platform of the horse-gin above the point on which it is to act. All the windlasses are placed on a second platform forming a kind of turn-table, placed high enough for the horse to pass under it, and on it stands the man attending to the working of the apparatus. Under the large platform of the carriage is placed a mechanism which is attached to the horse-gin, and which, by means of a chain, draws backwards or forwards the whole system, which moves on rails.

The machine is used as follows: The upper part of the ground is levelled; a line five meters wide is laid perpendicularly to the face of the rock to be cut and five or six meters back; the machine is placed on this line. A man stands on the upper platform, and turns the apparatus so that one of the arms of the crane shall be about over a cutting previously made in the soil to admit a wedge which will serve to detach the mass; the carriage is then advanced or drawn back sufficiently so that the strap of the two guiding rods being lowered, the wedge can pass between the two wooden blocks; these blocks are carefully wedged with waste stone, so that they lie firmly on the stone, which they can do from the slight oscillatory motion they can take. The monkey is then raised to the required height to detach with a single blow the block of granite corresponding to the position of the wedge. The nippers are loosened, and the monkey detaches a block of from five to ten cubic meters. The placing in position of the apparatus and detaching of the block takes five minutes. Enough men must be employed to prepare the places of the wedges, either in the blocks to be detached or in those already detached, which are to be broken up. Each hole for a wedge in the granite takes an hour to make. The inventor states that twelve workmen, each having a man to help him, would be required, also a man to guide the machine, and five men to move and load, in all 30 men. The machine itself can assist in loading the blocks, as it is a regular crane. For breaking up small blocks, a special machine, which reminds one of a pile-driver is used, only the monkey, which is comparatively light, has a projecting cutter on its lower surface, and which is perpendicular to another cutter on a fixed cast iron anvil. The top of this anvil is surrounded by a framework, into which is put granite dust to the level of the cutter on the anvil; on this dust the block to be broken is placed and kept in position by means of a stiff wooden bar. It appears that considerable saving results from these two machines. They possess the advantage of not being liable to get out of order like that which has been used in the environs of Fontainebleau, and which necessitates the use of a steam engine—a kind requiring men accustomed to the management of steam-engines. It must, however, be admitted that this machine is very cumbrous, and one would like to know whether, by adopting the principle of the use of very heavy masses, for cutting rocks, a means could not be discovered which would permit of its application in the earthworks in the limestone and granite strata which will be met with in great numbers on the railways authorized in 1868.

Engineering Architecture, says President Haughton, in his address before the Mechanical Engineers, is a subject which the Society would do well to keep continually before it, because it is a line in which we can see our way, and in which every one admits there is room for improvement; it is, indeed, humiliating to think of the vast sums that have been spent in England on grand engineering works, with an utter disregard of appearances. and where a modicum of æsthetic skill would have given us so much effect and beauty. It will be said that utility and not beauty should be the cry of the engineer; but this is, after all, only the twaddle of incompetency, for it is well known to those who have given attention to art, that it costs no more to arrange materials in effective and pleasing forms, than to pile them in the shapeless masses that attract the eye. We must at once dismiss the assertion that beauty is costly; it is not meretricious ornament that is advocated, such as may be seen in at least one of the latest engineering works.

What I ask you to aspire after in those engineering works upon which you are engaged, is form, in the æsthetic sense, in place of that deformity which is sown broadcast around us, in which the British engineer has hitherto glorified himself, and in which he would seem to wish to idealize and deify sheer strength, which in his simplicity he sees to be incompatible with beauty of outline. Let the engineer above all things refuse to entertain the thought that veneration for the beautiful is beneath him as a man, or derogatory to the dignity and character of his race; for during all times those races which made themselves famous for their prowess and their majesty, their power alike over matter and mind, were equally renowned for the beauty and for the magnificence of their public works—those monuments of glory by which, history apart, we can now alone judge of their aristocracy of race.

HEATING AND VENTILATION.

Compiled from the late report of Alban C. Stimers, Esq., on the Ventilation of the Hall of the U. S. House of Representatives.

The term ventilation when applied to a hall of this importance should signify the production and maintenance within doors of pure air, properly tempered with heat and moisture, regardless of the existing state of the weather. A consideration of the subject is therefore properly divisible into the following heads:

1. The quantity of air necessary and how it should be introduced.

2. Warming and moistening the air in cold weather.

3. Cooling and drying the air in hot weather.

The subject of regulating the degree of moisture in the air when it is neither warmed nor cooled, is naturally involved in the above.

THE AIR SUPPLY.—A cubic foot of air at a temperature of 65° with the dew-point at 52° will absorb $2\frac{1}{2}$ grains of vapor. Each person exhales 15 grains of vapor per minute, and also requires $\frac{1}{4}$ cubic foot for breathing, $=6\frac{1}{4}$ cubic feet of air vitiated by each person per minute.

In supplying air for the ventilation of such a hall, it is absolutely essential that the direction of the current should be vertical; otherwise that which has been vitiated by one person will be given to another. If this envelope of vitiated air be drawn upward, the nose and mouth will be always supplied with it, no matter how pure the air may be one foot away; while, if it is drawn downward, those organs will always be supplied with pure air. The temperature of the human body rarely varies 2° either way from 98°. If, therefore, the air is supplied at a temperature of 65°, it will be 32° cooler than the body; with the downward current the head will be in this cool air, while the feet will be enclosed in an atmosphere nearly if not quite as warm as the blood within them. And to "keep the head cool and the feet warm" is one of the fundamental rules of hygiene as well as of comfort. A current of air coming up through the floor will always carry the fine dust which the greatest care cannot prevent accumulating. With downward ventilation it is only necessary that the dust shall be thoroughly removed from the inflowing air at the mouth of the inlet to keep the hall free from dust. Again: with upward ventilation, the entire hall is filled with vitiated air, the vitiation having taken place near the point of admission; while with downward ventilation the vitiation takes place near the point of exit, and the whole upper part is full of pure air.

During the downward movement of the body of air in a high room, all eddying currents, induced by the increased velocity through the apertures, become quiet, and the whole mass descends with a uniformity impossible to obtain in the vicinity of the persons ventilated with upward currents; and one of the most important considerations to be kept in view in ventilating an apartment is to avoid perceptible draughts. The only limit to the amount of air that can be advantageously supplied, is the avoidance of sensible currents. Most people can feel a current having a velocity of 150 ft. per minute; very few can perceive one of 90 ft. The maximum velocity proposed in this case is 50 ft., and the hall being $139\frac{1}{3} \times 93$ ft. in plan, the quantity of air required would be 647,900 cubic feet per minute.

The first method adopted by engineers and architects to give movement to air, for the ventilation of mines and buildings, was to heat an upflowing column, thus lessening its specific gravity and causing it to rise with corresponding force. That system is still employed in the British houses of Parliament. It has been practically demonstrated, however, that one pound of coal burned in the furnace of a steam boiler, which furnishes steam to drive a fan blower, will generate as much force, and consequently is capable of producing as strong a current of air, as 38 pounds expended in heating a column of air to act by its diminished gravity. English engineers commenced about ten years ago to apply fan blowers to the ventilation of mines. The French had previously adopted this practice. In addition to the economy of this method, the complete control which the attendant is enabled to maintain over the quantity of air supplied at all times, is found to be of great advantage.

To propel the air into this hall it is proposed to place four fan blowers, having a capacity of 200,000 cubic feet per minute each, in the cellar; thence the air passes up through shafts to the chamber above the ceiling. Here would be placed an additional ceiling of plate glass and iron, of double thickness, that it might be a non-conductor of heat, and above this the gas burners. The air would thus be thoroughly distributed over the ceiling before passing into the hall. Such openings through the present ceiling would be provided, that its present ornamental appearance would not be changed, and an equal area of opening would be obtained in each of the 165 squares into which it is divided. To insure the continuance of the air thus admitted, in a direct vertical line down to the floor there would be frequent openings throughout their extent, which should communicate to the air-chamber beneath the floor. The air from this chamber would be withdrawn by means of four fan-blowers of equal dimensions with those employed to drive the air in. From the blowers the air passes up through a separate duct, by the side of the pure air duct already mentioned, and goes off through the roof.—All these blowers would be driven by one pair of engines of 750 h. p., through the medium of appropriate gearing, shafts and belts. In every case of gearing there would be wooden teeth working into a cut metal gear, which, may be made to run with perfect silence, and is more durable than metal gearing. By running all the blowers from one engine, a uniform relation of the forces employed in different localities is secured.

Merely forcing fresh air in, would drive the foul air out, but this would mostly occur through the nearest and easiest passages, so that the fresh air would not be properly distributed. Simply drawing air out would cause in-currents from all doors and windows as well as from the intended supply duct. Excess of either induction or withdrawing forces would tend to produce these respective results. The only perfect distribution of the air will result from having the filling and exhausting forces the same.

The present place of admitting the air, near the ground, is very objectionable. Even admission by high towers would not secure air free from dust. The plan here proposed is to sink a shaft 25 ft. in diameter, some 200 ft. west of the building, in a small grove. Over it would be erected a substantial screen, 22 feet in height, and similar in form to the Capitol dome. It would be made of $\frac{1}{4}$ wire of pure block tin, that it might be durable and always clean. The meshes would be about $1\frac{1}{4}$ inch. Over the top of this there would be a revolving fountain with four jets, which would project downward, throw small streams of water with force upon the wire work of the screen, and keep every wire covered with an envelope of clean water, against which the entering air would have to rub in passing in. This forcible contact would transfer the dust from the air to the water. The muddy water would fall to the bottom of the duct and pass away by the drain through a trap. From the bottom of this vertical opening a tunnel 15 ft. in diameter would extend horizontally to the blowers in the cellar so enclosed as to draw their air wholly from this source. The tunnel is 15 feet in diameter, and the top of it passes 16 feet below the lowest point of the foundations of the building.

Warming the Air in Cold Weather.—There are three methods in common use for warming air; by passing it over, 1st, iron surfaces heated directly by fire; 2d, iron pipes filled with steam; and 3d, iron pipes filled with hot water. The first method is considered highly objectionable in first class buildings. When air is brought in contact with highly heated iron surfaces, especially rusty surfaces, an unpleasant odor and feeling are imparted to it, from the decomposition of those ammoniacal matters which are always found more or less in the atmosphere, and from its extreme dryness. Zinc surfaces are a great improvement over iron, in this respect, but block tin is considered the best material, as it resists atmospheric influences better than any other of the useful metals.

The means here recommended are pure block tin tubes filled with hot water, each tube being 10 feet long by $1\frac{1}{8}$ inches outside diameter and secured into brass tube-heads in the same manner as in the surface condenser of a marine engine. They open at each end into steam-tight chambers; into the upper chamber steam from the boilers is introduced, and from the lower one water is drawn off by appropriate pipes. It will be understood that with this arrangement the apparatus may be a steam heater, or, if the surface is enlarged enough to warm the air with hot water, the steam will be condensed in the upper chambers, hot water filling the bottom of the tubes and the lower chambers. A valve in the pipe through which the water flows away would control the rapidity with which it was drawn off and consequently its temperature. In ordinarily cold weather this would be a hot water warming apparatus, but upon any extremely cold day it would become a steam heating apparatus as the attendant opened the regulating valve in the drain pipe.

Moistening the Air.—The water thrown off by the human body, evaporates in the surrounding air. The rapidity of this evaporation is dependent entirely upon how far the condition of the air in regard to moisture is removed from the point of saturation. In ease the evaporation from our bodies is too rapid, the skin becomes too dry, and this again induees too rapid a flow of the water within the system toward the surfaee, making us uncomfortable, and sometimes ill. Evaporation is also a cooling proeess. This is explained by the absorption of the latent heat which occurs upon the eonversion of a liquid into a vapor. On the other hand, if the evaporation is too sluggish, the flow of water toward the surface is retarded and we are made uneomfortable and sometimes ill in another way; also, if the air is of the proper temperature, we are uneomfortably warm, the general feeling being described by the term "muggy." It is highly important, therefore, that the proper moisture of the air should be maintained in any system of ventilation.

An authority on this subject* says: "Air changed in temperature by warming, *without increased moisture*, produees unpleasant sensations in the head and ehest, etc. The objection lies against heated air, no matter how heated. The only way that hot air can be made healthful is by an effectual plan of artificial evaporation." Professor Henry says on this subject: "The heating af the air and preserving it at the desired temperature is the simplest part of the problem; to remove the impure air and to supply its place with fresh air, without giving rise to unpleasant eurrents and unequal temperature is more diffieult; to supply the proper quantity of moisture and to prevent its eondensation is attended with still greater diffieulty, particularly when apartments containing a large number of persons are to be thoroughly ventilated. This part of the general problem is, in my opinion, an essential element of proper ventilation, although it has hitherto reeeived eomparatively but little attention in this eountry."

Mr. Stimers' plan for moistening the air is by placing in the air duet, a system of water pipes, 10 in number, each 20 feet long, lying horizontally, lengthwise of the duet, and distributed throughout its cross seetion so as to equally divide it up. In each of these pipes there would be a great number of minute holes extending all around the cireumference and throughout the length. The water driven into these pipes with forec would spin out of these holes radially from each pipe, filling the entire duct with a fine shower.

*Dr. Youmans Hand-book of Social Science.

The "relative humidity" of the air is the percentum which the amount of moisture in the air is, of that necessary to saturate it at the same temperature. A relative humidity of 65, with a temperature of 65°, is assumed; this corresponds with

$4\frac{1}{2}$ grains of water per cubic foot of air.
A tension of 0.4 in. of mereury.
A depth of $5\frac{1}{2}$ in. of water on the earth.
A break between the wet and dry bulb thermometers of $5\frac{1}{2}$°, and
A dew point of 52°.

The lowest degree of humidity of the external air of Washington, as reported by Dr. Wetherell, was 1.11 grains per eubie foot. Assuming one grain for the base of ealculation, there will have to be added $3\frac{1}{2}$ grains per eubie foot to give it a relative humidity of 65 when at a temperature of 65°, and as there are 7,000 troy grains in one pound avoirdupois, 80,000 eubie feet of air will require $\frac{80{,}000 \times 3\frac{1}{2}}{7{,}000} = 40$ pounds of water per minute.

The temperature of the water would probably be about 40°. This would have to be warmed to 65°, and be supplied with the latent heat necessary to form it into vapor at that temperature.

To aseertain how much the air must be superheated for this purpose—

Let s = specifie heat of air as eompared with water .... = 0.2669
v = volume of air in eubie feet.... = 80,000
w = weight of air in lbs. per e. ft.. = 0.075
t = temperature from which water is raised.................. = 40°
t' = temperature to which water is raised .... = 65°
l = latent heat of steam at that temperature............... = 1070°
W = weight of water to be absorbed in pounds................. = 40
x = number of degrees the air must be heated above 65°, in order that it may be at that temperature after it has dissolved the moisture.

$$\text{Then } \frac{W\,(l + t' - t)}{svw} = x = 27°.$$

The temperature to which the air must be raised, under the above conditions of the weather, before it is moistened, would therefore, be—

$$65° + 27° = 92°.$$

To determine the extent of surfaee required for the warming tubes—

Let P = temperature of water in tubes = 192°
T = temperature of air after heating...................... = 92°

Let t = temperature of external air.. = 20°
C = volume of air in cubic feet... = 80,000
S = surface of tubes in square feet.

$$\text{Then } .0045\, C\, \frac{(P-t)\,(T-t)}{P-T} = S$$

and $S = 44{,}582$ square feet.

Each tube being 10 feet long by $1\frac{1}{8}$ inch diameter, would have a surface of 2.9 square feet. There would, therefore, be required 15,373 tubes. These are divided into eight several congeries, for convenience of construction, with 1,922 tubes in each. It is proposed to arrange indicators in the engine room, so that the engineer would always know the exact temperature and moisture in the hall, and could regulate the heat and water accordingly.

Cooling and Drying the Air in Hot Weather.—An attempt has been made to cool the air of this hall with ice. Some two tons of ice were melted in the air-duct during each day of about five hours, say 800 pounds per hour. The quantity of air passing through the duct, per minute, was 24,300 cubic feet.

The temperature of the ice was, say .... 25°
That of the water of condensation was, say, 60°
The latent heat of the ice is .... 140°

To determine how much the air would be cooled by melting the ice—

Let t = temperature of the ice....... = 25°
t' = temperature of the water of condensation .... = 60°
l = latent heat of ice............ = 140°
s = specific heat of air .... = .2669
w = weight of air per cubic foot.. = .075
v = volume of air in cubic feet... = 24,300
W = weight of ice melted per min., = $13\frac{1}{3}$
x = number of degrees the air would be cooled by the melting of the ice.

$$\text{Then } \frac{W\,(l+t-t)}{swv} = x = 4\tfrac{3}{4}°.$$

As, however, the air thrown in by the blower was mixed up with that which flowed into the hall through the open doors, the temperature of the hall was only reduced about one degree by the melting ice.

Taking the maximum temperature at 95°, and the maximum moisture in the air at nine grains per cubic foot; to reduce the temperature to 75°, and the relative humidity to 65, we must abstract three grains of water from each cubic foot, or $\frac{80{,}000 \times 3}{7{,}000}$ = 34.3 pounds from the whole quantity per minute. At the moment of the condensation of this water, from a vapor into a liquid, its latent heat is given out into the air; so that removing the vapor is a warming process. The additional extent which the air must be cooled to compensate for this is expressed by the formula—

$$x = \frac{W\,l}{s\,v\,w}$$

Where W = the weight of water in lbs. = 34.3
l = latent heat of the vapor.. = 1091°
s = specific heat of air....... = .2669
v = volume of air in cubic ft., = 80,000
w = weight of air per cubic ft., = .075
x = the number of degrees the air will be warmed by the condensation of the vapor.

With the above values, $x = 24°$.

The entire cooling effect must, therefore, be equivalent to 44°. This would require 24,000 pounds of ice to be melted per hour, or, say, 60 tons per daily session of five hours.

Coal is cheaper than ice per ton, and more conveniently stored and handled. One-sixth of the above quantity burned in the furnace of a steam-boiler will produce, through the medium of appropriate mechanism, an equal cooling effect upon the air. Machines are operated by the steam engine for the manufacture of ice, which produce cold by pumping off the vapor of sulphuric ether, or of the bisulphide of carbon; these liquids vaporizing rapidly at low temperatures if the pressure of the superincumbent atmosphere be removed; but the employment of such substances would be inadmissible in cooling the air for ventilation, as a slight leak in even one of the many necessary tubes would impair the purity of the air to a sensible and objectionable extent.

Mr. Stimers, therefore, proposes to employ the steam power to drive air-pumps to compress a portion of the air, making it hot, and while under this pressure to cool it down to the ordinary temperature by passing it through tubes surrounded by flowing water, (employing an apparatus precisely like the surface condenser of a steam engine,) and then let it expand into the duct. This expansion would be a cooling process exactly corresponding in extent to the heating one the air underwent when it was compressed, and by mixing this excessively cold air with the warm air from the blowers, the whole would be brought to the desired temperature.

It is mechanically convenient, in a machine of this kind, to compress two volumes of air into one, in the pumps. To learn how much such an amount of compression would elevate the temperature, a formula is given by Peclét*, as follows :

* *Traité de La Chaleur ; tome III, p.* 10.

Let θ = temperature before compression (Centigrade).
d = density before compression.
θ' = temperature after compression.
d' = density after compression.

$$\text{Then } \theta' = (274 + \theta)\left(\frac{d'}{d}\right)^{0.42} - 274.$$

In this case

$$\theta = 35° \ (= 95° \text{ Fahr.})$$
$$d = 1$$
$$d' = 2$$

and consequently

$$\theta' = 139.44° \text{ Cent. or } 283° \text{ Fahr.}$$

and the elevation of the temperature would be 188° Fahr.

To find how cold the air will be after its expansion, we have

$$\theta = \frac{\theta' + 274}{\left(\frac{d'}{d}\right)^{0.42}} - 274.$$

Assuming 20 lbs. pressure in the air condenser, and 75° Fahr. (23.89° C.) temperature of the water: as the heat was abstracted from the air it would be further condensed $\frac{1}{480}$ part with the departure of each additional degree, the pressure being maintained; hence we would have

$$\theta' = 23.89$$
$$d = 1.$$
$$d' = \frac{14.7 + 20}{14.7} = 2.36,$$

whence $\theta = -66.12°$ Cent. or $-87°$ Fahr.

This would be a reduction from its original temperature of 182°. This being slightly more than four times the amount of cooling force it is necessary to apply to the whole quantity of air furnished, one-fourth of that amount, or 20,000 cubic feet, will require to be passed through the pumps. The dimensions of the air-pumps and engines will be as follows:

Number of pumps	2
Diameter of pistons	65 inches.
Stroke of pistons	6 feet.
Double strokes per minute	40
Diameter of steam cylinders	45 inches.
Steam pressure	40 lbs.
Gross effective steam pressure	29 lbs.
Horse-power	1,200.

If the cold air was simply conveyed to the air-duct and mixed with the warm air from the blowers, it would be cooled down below the desired temperature, and a portion of the moisture it is desirable to abstract would be condensed in the form of a fog and carried along with the air into the hall, which would thus be filled with a cold, damp air, highly objectionable. It is necessary, therefore, to have the cold air introduced in a peculiar manner, such that not only may the moisture be abstracted, but that the exact amount removed may be subject of convenient and easy regulation by the engineer in the engine-room. The character of this regulation must necessarily be that the power exerted by the engine shall determine the extent of the cooling force, and that the amount of this which shall be devoted to reducing the temperature of the air, and that which is devoted to abstracting the moisture, shall be subject to a regulating lever, or hand-wheel; so that if the engineer moves this in one direction, the air will be made cooler and more moist, and if in the other, it is made warmer and dryer, the cooling engine continuing to run at the same rate.

To accomplish this it is proposed to erect, in each of the two cooling and drying chambers of the air ducts, a congeries of tubes somewhat similar to those employed for warming the air in cold weather, only there would be an additional chamber, or chest, at mid-height; in fact, two systems of tubes, one above the other; in other words, it would be two stories high. In the two upper chambers there would be openings in the bottom in all the spaces between the rows of tubes; these openings controlled by valves, and the valves appropriately connected with hand-levers in the engine room; there being one for a system of valves which would control the openings in every third space between the rows, and one for those in the remaining spaces. The aggregate area of the openings in the lesser system should equal the area of the pipe which brings the compressed air from the cooling engine; those in the other spaces, being of the same dimensions, would have in the aggregate twice this area. Then the compressed air should be conveyed by a pipe from the cooling engine to the lowest chamber, thence it would flow upward through the tubes into the upper chambers, then downward through the openings into the spaces between the tubes. The operation of this arrangement would be as follows:

Let us imagine a condition of the external air such as has been assumed for a maximum performance of the cooling engine. In this case let the openings in two-thirds the spaces between the tubes be closed, and those in the remaining spaces be wide open; the area of the whole being such that it would require a pressure of 20 pounds per square inch to drive all the air supplied by the pumps through them. It will be perceived that the pressure throughout, from the pumps to the exit, will be 20 pounds per square inch, and that, therefore, the temperature will be maintained at 75° while the air passes through the tubes. As the compressed air pours down between the two rows of tubes, and expands to the ordinary atmospheric pressure, its temperature will fall so suddenly that the moisture within it will be condensed, and part of it frozen into minute hail. The main portion of the air from the blowers will pass through the remaining spaces between the tubes, and as they are only one-eighth of an inch apart in the rows, they form, in effect, walls of separation between the warm and the cold air A sufficient quantity of the air from the blowers will, however, pass into the cooled spaces to carry forward the hail storm raging there, and as the hail and condensed moisture are carried along the narrow spaces they will come in contact with the surfaces of the tubes and be deposited upon them. The temperature of these will be too low to vaporize the moisture, but warm enough to melt the hail, and the water will run down them, as it does along the sides of an ice-water pitcher, to the bottom tube-sheet, whence it will pass off in proper drains prepared for it.

If the warm air issued from the dryer with the same velocity as the cold, exactly one-third of the whole amount would be excessively cooled, and nearly all its moisture extracted; but the great velocity with which the compressed air will pour into the spaces between the tubes, having only to be changed in its direction by the horizontal current from the blowers, will flow out with considerably greater velocity than the warm air from the remaining spaces; so that something more than one-third of the moisture contained in the whole amount of air will be deposited upon the tubes and carried away. In the case under consideration, exactly one-third is the amount it is desired to extract. The necessary reduction will be made by slightly opening the valves in the remaining spaces; the immediate effect of which will be to cool down all the tubes by causing a partial expansion of the air within them; so that the warm air will be cooled somewhat by coming in contact with the tubes, in addition to having some of the cold air mixed with it. This will lessen the extent to which the temperature will be reduced in the cold spaces, and, consequently, the amount of moisture will be condensed and extracted.

To enable the engineer in charge to control the condition of the air delivered to the hall, it is proposed to place pipes about three inches in diameter, and properly incased with a non-conductor, from the inlet duct, from the tempering ducts just beyond the moisteners, and from the hall; leading them through a convenient place in the engine room, for observation, to the suction openings in the blowers, which would cause a rapid flow of air through them, having the exact condition existing at the other ends of the pipes. Into each of these pipes, as they pass through the engine room, the wet and dry bulbs of a hygroscope would be inserted, which should plainly indicate the temperature and degree of moisture in the air passing through the pipes.

The method here recommended for drying the air when it is too moist, or when it is made so by reducing its temperature, is simply the adoption upon a small but sufficient scale of that employed by nature in effecting similar changes of weather.

Cost.—The actual cost of the complete apparatus described, is estimated by Mr. Stimers at $688,653. The following are some of the items:

Eight blowers and shafting for 200,000 c. ft. per min. each	$11,194
Pair of engines 750 H. P., with wood gear fly-wheel, erected complete	46,102
Four boilers, with 13,744 sq. ft. surface, and of 1,370 H. P.	63,416
Heating apparatus, with 44,582 sq. ft. block tin tube surface, with steam and water pipes and valves	123,018
Pair of condensing engines of 1,320 H. P., with 45 in. steam cylinders, and 65 in. air cylinders, 6 ft. stroke and a cooler with 9,000 sq. ft. brass tube surface, erected complete	94,552
Drying apparatus, with 5,570 sq. ft. block tin tube surface, with valves, complete,	30,754

Steam Farming Power.—It is but a very few years since a portable engine for farm use was a curiosity, nor is it so very long since such a thing was unheard of. Now, we find a single establishment capable of turning out a thousand yearly, of a design and finish equal to the best locomotive practice. There are at least four makers in Lincoln alone, one of them having magnificent works. More than 15,000 portable engines are known to have been sent out during the last eighteen years.—*Engineering.*

Fastening Cast Steel Driving Tyres. — The following rules, for shrinking on cast steel tyres, were issued by W. A. Robinson, Mechanical Superintendent of the Great Western (Canada) Railway:

1st. Both tyre and wheel must be perfectly cylindrical.

2d. These tyres are to have allowed, in their cold state, the amount of shrinkage shown in the following table, according to their respective diameters:

Letter of tyre.	Internal diameter of tyres.	ALLOWANCE FOR SHRINKAGE.		
		Decimal parts of an inch.	Fractional parts of an inch.	Wire gauge.
A	Ft. In.			
B	2 2¼	.014583	1–69	28
C	2 8	.017	1–56	27
D	2 9	.0183	1–54	26
E	3 2	.021	1–49	25
F	3 4½	.0225	1–44	24
G	3 8	.024	1–41	23
H	4 3¼	.028472	1–35	22
J	4 7	.0305	1–33	21
K	4 8	.031	1–32	21
L	5 2¼	.034583	1–29	20
M	5 3	.035	2–57	20
N	5 7⅞	.0377083	2–53	20
O	5 9	.0383	1–26	19

3d. Wood only is to be used to heat the tyres, and temperature must not be allowed to exceed a dark red glow in the shade, and all parts must be heated equally to insure uniform hardness and roundness. To facilitate the operation, each foreman is provided with a set of steel gauges corresponding to the above figures.—*American Railway Times.*

Steel Rails, Tyres and Fire Boxes. —The last report of Mr. Sayre, Superintendent and Engineer of the Lehigh Valley Railroad, treats these subjects as follows: "I have seen no reason to change my opinion of the value of steel rails as compared with iron; another year's wear has made no perceptible impression upon the 200 tons, the first of which was laid in May, 1864, none of which have broken or given out since last report. These rails have had a severe test, being in those places in the track where they are subject to the greatest wear, and being laid with a chair which is much inferior to the most approved joint now in use. * * * There is no longer any possible doubt as to the superiority of steel over iron in economy, as in every other respect." The report goes on to say that a large additional quantity of steel rails and a few steel headed rails have been contracted for.

As to steel tyres, the report say: "The experience of the past year has confirmed our favorable opinion of steel tyres. There were on the road at date of last report 57 locomotives furnished with steel tyres." This number has now been increased by 19 engines. "Although in one or two instances they have not done as well as we could wish, yet none of those of reliable manufacturers have failed, and the result in general has been very satisfactory. "The steel tyres of engine No. 25 put on December, 1863, have made 106,185 miles and are good still.

There were steel fire boxes on 14 engines at the date of former report. "All have given good satisfaction during the year except those of engines 50 and 51, which were not of good quality and have given us continual trouble. We now have in use 29 fire boxes of steel. The first one, put in January, 1862, is still good. All the engines contracted for, or which we build ourselves, are furnished with steel fire boxes and tyres."

The Darien Ship Canal.—By Mr. Cushing's mission, all political obstacles to the construction of this great work are removed; it is understood that American engineers have secured from the Government of New Granada, both the right of survey and the right of way across the Isthmus. A company including Peter Cooper, Marshall O. Roberts, Wm. H. Vanderbilt and other equally well known capitalists, was chartered by the New York Legislature last winter, and have since become fully organized as a joint stock company to undertake the work.

Many routes have been surveyed, but that from the Gulf of San Miguel to Caledonia Bay, and the one from Bayone River to the Gulf of San Blas have appeared most feasible. The latter route has deep and spacious harbors and would require but 30 miles of canal. The tunnel through the Cordilleras would be seven miles long, 100 ft. wide and 115 ft. high to allow steamers to pass, and even a first-class man-of-war, with her topmast and top-gallantmast struck and her yards braced.

THE HOOSAC TUNNEL.

The contract for this work, between the Messrs. Shanly and the State, made Dec. 24, 1868, is published in full in the "American Railway Times" of Jan. 30, 1869. The tunnel, central shaft and one track are to be completed by March 1, 1874; the price to be paid is $4,594,268. A delay in the rate of progress through the most difficult part is provided for, but the final delay must not exceed six months, and if the State decides that the contractors are not making the necessary average progress, it may give them three months' notice to quit the work. No payment is to be made to the contractors until they have earned $500,000; but 20 per cent. of the monthly amounts of pay earned is to be reserved for final payment on completion of the whole work; and, for 80 per cent. of each monthly amount, certificates in the sum of $200,000 each, bearing five per cent interest are to be issued, and to be paid in the order of their issue as often as it shall appear that the contractors have earned so much that after reserving the 20 per cent., the State will still retain in all, $500,000. The intention is that the State shall make no payment which will at any time reduce its security from the reserved fund of 20 per cent. below the said half million dollars.

The size of the tunnel, in rock, is 24 feet clear width and 20 feet height; where arching is required, 26 feet wide and $21\frac{1}{2}$ feet high. The central drain is 2 feet square. At the east end, the work done is 2,500 feet of tunnel, part of which is full size, and 2,782 feet of heading; the work to be done is tunnel enlargement 4,500 yards, heading enlargement 28,000 yards, tunnel extension 5,300 feet long=85,100 yards, trench and pipes 5,600 feet long, and the railroad track. At the central section the work done is sinking 583 feet of elliptical shaft 27 by 15 feet; the work to be done is to make a fire-proof floor with self-closing iron hatches, to sink the shaft to a depth of 1,030 feet (floor of tunnel) to set up two ten-inch iron pipes for power and ventilation, and to excavate the tunnel east and west to meet the end workings, with drain and track. The work done at the west end is a shaft 318 feet deep, 8 by 14 feet, and headings from it 1,609 feet east and westward to the west end, a pumping shaft 277 feet deep, and an auxiliary shaft 215 feet deep. The work to be done is enlarging the headings (52,800 yards), extending the tunnel east to meet central working, arching part of the tunnel with brick ($4\frac{1}{2}$ million bricks to be used), and the end with stone, having a suitable facade, and laying drain and track as above. The State gives the contractors the use of all plant, tools, &c., on hand.

As a more rapid progress of the work is required than drilling by hand labor would accomplish, upon each of the advance headings, between the east portal and west shaft, the contractors will be required to use pneumatic drills, working continuously not less then eight drills to a heading of eight feet height, with not less than 50 lb. air pressure, but with the liberty to employ the form of machine now in use in the tunnel, or any other drill of equal efficiency which they may prefer and provide at their own expense.

The prices for the work, fixed to determine the monthly amounts earned, are as follows:

Tunnel enlargement, per yard............	$16 00
Heading enlargement east end, per yard..	9 00
Heading enlargement west end, per yard..	9 75
Full size tunnel extension east end, pr yard	11 00
Full size tunnel extension central section, per yard............................	14 00
Full size tunnel extension west end, pr yard	12 00
Central drain with air and water pipes complete, per lineal foot	13 00
Sinking shaft (27×15 ft), per foot in depth	395 00
Pipes (10 in.) set in shaft depth..........	6 00
Arching with brick (at $9 per M.) per M..	22 00
Excavating and constructing 50 linear ft. of stone arch and filling.............	23,000 00

The extreme length of the tunnel will be about $4\frac{3}{4}$ miles, of which some three miles are yet to be excavated.

THE PITCH LAKE OF TRINIDAD ever and anon claims the attention of the public. At one time it is introduced as the source from which all the varieties of mineral oil, paraffine and asphaltum can be obtained. At another period it is to be employed to give greater illuminating power to our coal-gas, and some experiments of the Hon. Captain Cochrane, made at Woolwich, were highly favorable. Now we have the pitch of Trindad coming before us as an ingredient in artificial fuel for steamers. The bitumen is mixed with a certain quantity of charcoal: it is ground, and then made into bricks. Experiments made on board H.M.S. "Gannet," appeared to show that it possessed many valuable properties, but the amount of ash, arising from the earthy matter mixed with the petroleum, was somewhat objectionable. This can, however, in all probability, be obviated by greater attention in the process of manufacture.—*Quarterly Journal of Science.*

MINING.

PRESERVATION OF HEALTH AND LIFE—MINING MACHINERY.

From the "Quarterly Journal of Science."

The shortness of the average duration of a miner's life has often been the subject of the most serious consideration. The Royal Commission, of which Lord Kinnaird was the chairman, made this portion of their inquiry a most searching one. It is clear, from the evidence given by medical men and others, that the metalliferous miner suffers in health from climbing on the perpendicular ladders from great depths, from working in air deficient in oxygen, and from the severe labor of boring holes for blasting in confined levels. The constrained position of the man in "beating the borer," and the muscular effort necessary to deliver the heavy blow, act injuriously upon the heart and lungs.

The miner has been relieved to some extent from the effects of climbing, by the introduction of the "man-engine" (a movable rod with platforms fixed upon it, by which the miner is gradually lifted—without fatigue to himself—from any depth to the surface). The ventilation of the mines generally has been improved, but it is only within the present year that any actual experiment has been made in the mines on the use of machines for boring holes, worked by compressed air or steam. We have been favored, upon application, with the following report. We are glad to place this on record, as the commencement of an application of machinery to a most important purpose. We have no doubt that in a short time boring-machines will be generally adopted in our metal mines.

"Dœring's rock-boring engine has been worked on the 185 fathom level in Tincroft Mine, conjointly with another, from the 6th of January up to the present time, and has driven sixteen fathoms in hard Tin Capel, which Captain Teague considers would cost 20*l*. per fathom if driven by hand-labor. During the greater part of this time, in consequence of the air-pumps getting constantly out of repair, the machine was only worked by one (shift) corps of two men; and continuous working with three corps, comprising five men and one boy, only commenced on the 6th of July. Since this date nearly nine fathoms of ground have been driven, at a cost of 17*l*. 16*s*. 2*d*. per fathom. The following is the cost of working the machine during the last month:

	£.	s.	d.
Five miners and one boy	24	0	0
One boy to remove rubbish	2	0	0
Two enginemen at surface	6	0	0
One smith and boy	5	5	0
Oil, waste, and candles	3	9	0
Gun-cotton for blasting	4	10	0
Fuse	0	7	6
Sundries	0	3	0
Coals	6	0	0
Repairs	2	0	0
	£53	14	6

"In the above estimate the sum of 21*l*. 5*s*. is for expenses at the surface, which would be but slightly increased if three ends were driven instead of one—say about 2*l*. 15*s*. This would reduce the average cost per fathom 13*l*. 9*s*. 10*d*., instead of 17*l*. 18*s*. 2*d*. During these last three months one corps has been worked by one man and a boy, and the result has shown that they will drive as much ground with the machine as two men could do in the same time. (Signed) F. B. Dœring."

We find, during a recent visit to the Cornish mines, that the patentee is offering to contract for sinking shafts and driving levels upon such terms as will, without doubt, induce many mine adventurers at once to close engagements with him.

General Haupt's machine for boring is about to be introduced into the lead mines of Swaledale, in Yorkshire; and Mr. Lowe's machine is in use in several large railway cuttings and tunnels.

Our miners must (in consequence of improved mining abroad) direct their attention towards the application of machinery, so as to economize in every direction—not merely in the subterranean mining, but in all the surface operations. Necessity—the mother of invention—has already done much in this way; but there is yet ample room for very considerable improvement in the modes of working our mines, and in the methods of dressing the ores for the market.

In connection with this subject we may name—as we do with satisfaction—the increased desire on the part of the Cornish miners to avail themselves of the many advantages offered to them by the Science Classes of the "Miners' Association of Cornwall and Devonshire." We learn that four classes are now in operation in the mining districts around Helston, in which sixty working miners are proving themselves apt students of Chemistry, Mineralogy, Geology and Mechanics. One class of nearly thirty is no less actively engaged at Redruth, another in the mining parish of Gwennap, while a seventh have been recently been formed in the northern portion of the important mineral district of St. Just. The advantages which must result from these classes will, ere long, be felt in the improvement of mining and in the elevation of the miners.

The explosions of fire-damp in some of the coal mines of France has naturally drawn attention to the subject of ventilation. M. Galy-Cazalat, who has brought the matter before the Académie des Sciences, proposes the construction of vertical air-pits, the purpose of which would be to draw off the carburetted hydrogen as rapidly as it is formed, and thus prevent its mixing with the air of the mine. These "*cheminées d'aspiration*," as he calls them, will scarcely require very special description, the whole plan really resolving itself into a greatly increased number of shafts, by which the air in every part of the mine may be rapidly changed. There can be little doubt that great advantages would arise from such a system: but in the large and deep collieries of this country there are many serious difficulties standing in the way of its introduction.

M. Delaurier has brought before the Academy of Sciences a plan for *destroying* fire-damp in coal-mines. He proposes to place copper conductors of considerable thickness in the galleries; these are to be broken at intervals, and united by means of very thin gold wire, which is to be covered with sulphur. By passing a strong current of electricity through those conductors, the sulphur is ignited, and if any fire-damp be present it will be fired. This idea is by no means new. The Academy is said to have spoken approvingly of the proposed plan; but all coincided in the opinion that regular and powerful means of ventilation could in no case be dispensed with. The combustion of the *fire-damp* would produce *choke-damp*, which it would be necessary to remove. This plan, like many others which are from time to time brought forward, evidently originated with one who was but imperfectly acquainted with the conditions under which fire-damp is formed in a colliery.

CALCULATING AREAS.—Mr. J. L. Haddon, Chief Engineer to The Syrian Government, communicates to "the Engineer," his method of simplifying the tiresome calculations necessary for taking out areas, more especially when of curved or irregular surfaces

Principle.—Take paper of good manufacture (tracing or otherwise), and it will be found that its substance is very accurately distributed; any one square inch weighing precisely the same as any other—even in common papers it varies but slightly. The thicker the paper for my purpose the better.

Example.—Required to find the area of any map.

The paper on which the map is drawn is first to be accurately squared, the area thereof computed in inches, and its weight accurately ascertained. Next proceed to cut out carefully all that portion, the area of which is required, and weigh that also. Then as the weight of the whole is to weight of the portion cut out, so are their respective areas.

Suppose the scale of map to 20 miles = 1in., size of map, 20in. × 10in. = 200 square inches; weight of map, say, 2,000 grains. Then if weight of piece cut out is 1,500 grains, the area of it will be 150 square inches or 3,000 square miles.

In cases where the plan or map is valuable and it is not advisable to destroy it, a tracing of the part required has to be made, and the same process gone through for finding its area.

For iron sections, earthwork calculations, agricultural surveys, etc., it will be found most useful.

THE SICILIAN SULPHUR MINES have been long known. More than 600 mines have been at work, and at least 200 worked out and abandoned. The mining is of the most primitive character, the use of machinery being extremely limited. Not less than 22,000 people are occupied in working those mines, and the result is the production of sulphur to the value of not less than 17,600,000 francs per annum. The sulphur ores of Spain are now largely imported into England, and during the past year, not less than 500 tons of copper have been separated from sulphur-ash, after the sulphur has been expelled by burning, although the pyrites does not contain more than from 1 to 2 per cent. of that metal.

AGRICULTURAL IMPLEMENT MUSEUM.—Under the title of a Permanent Exhibition of Inventions and Improvements, a new section has been added to the Museum of Agriculture in Russia, the object which is to supply those who have invented or improved agricultural machines, implements or methods, with ready means of communication with agriculturists and the public. The machines, models, plans or drawings are to be exhibited gratis for six months, at the expiration of which time they will be returned to the inventors or destroyed, unless they should have been purchased for the Museum.

THE PIG IRON MANUFACTURE.

The great primary want of the manufacturer of malleable iron and steel, is better qualities of pig iron, such as can be produced from blast furnaces of the most approved construction. As a rule it may be set down that all the inferior ore and fuels may be worked to produce comparatively good results, when proper attention is paid to the details of construction of the furnaces, and preparing the materials for use, combined with skillful attention to the details of the manufacture. Every one familiar with this branch of science, is aware that the impurities contained in the materials are to some extent absorbed in the metal in the smelting operation, and that in numerous instances the fuel is very impure and imparts its deleterious properties to the pig metal. Hence it must be obvious that any means that will promote economy in the use of fuel will obviate this difficulty to the extent of the saving of the fuel. The improvement of pig iron is to be obtained by increased size and height of the furnace and by the use of a highly heated, uniform temperature of blast. A combination of these improvements are necessary to obtain the best results, for it has been found that with the same temperature of blast, in furnaces of fifteen feet bosh, given materials will produce inferior qualities of metal, while by using larger furnaces they produce improved grades of iron at a greatly diminished cost of production. To illustrate this we give the working of blast furnaces in the Cleveland district in England, using lean ores containing large percentages of sulphur and phosphorus, and as a rule with very inferior fuel. About six years ago the size of furnaces in this district varied from 14 feet to 18 feet boshes and about 50 feet high; the iron was unfit for any purpose where good quality was desired. Since the high, large furnaces have been adopted, with blast heated to 1,000° to 1,200°, the quality has improved to such an extent that the pig is now used for almost every purpose except the manufacture of steel. The most noted and successful examples of the large improved furnaces, are those of the Norton Iron Co. at Norton, England, and the Ferry Hill furnaces; they are respectively 25 feet boshes and 85 feet high, and 27 feet boshes and 102 feet high. These furnaces make the ton of best foundry iron with 17 to 19 cwts. of coke. The Norton furnaces, owing to more skillful engineering in the design and construction, produce more iron per week than the Ferry Hill furnaces, although considerably smaller. A large portion of the excellent results of these furnaces is attributed to the use of superior heating stoves for heating the blast, known as Player's patent. There are large numbers of these excellent stoves at each of the above works. The blast is generally heated to about 1,200°, which is maintained with great regularity. The Norton furnaces were designed and built by John Player, an engineer of considerable experience, now residing in New York. The production of one of these furnaces is nearly 600 tons per week. The ores average 42 per cent.

The commercial value of the improved furnaces, as compared with the old style now obselete in Cleveland, is so great that upwards of 50 furnaces in good repair, are abandoned and will never be blown in again. Six years ago many furnaces "blew out," when pig iron reached 65s. per ton with labor and material cheaper than they now are; since then the large furnaces have been put at work and can sell pig iron at a profit at 40s. per ton. At many works in the United States, by remodeling and adding the Player stoves, results are now obtained that approximate nearly to those given in the large English furnaces; this is to be attributed to the superiority of the ores and fuel used here, more especially our admirable anthracite, than which there is no better fuel for the manufacture of pig iron, excepting of course charcoal, which is gradually becoming scarcer every year and is left out generally in calculations for a large continued business. There are also many instances among our American furnaces (to which we shall refer in detail on another occasion) of larger production and improved quality, due to the improved hot blast stove; the reduction of fuel in some instances is said to be 50 per cent with a corresponding increase in the production of the furnace and with the highest grade of iron where only ordinary iron was previously made.

The advantages of large furnaces (when suited to the materials) over smaller ones is so great that pig iron makers should no longer hazard the building of small furnaces; the difference in the cost of production in two years will clear the cost of the large furnace. From the results abroad, and the better practice just beginning here, it will be seen that improvements actually exist, which, when fully applied to this industry in America, will revolutionize, not only the manufacture of pig iron, but the manufacture of cheap and good malleable iron and steel.

FLYING MACHINES.

PRINCIPLES—EXPERIMENTS—THE LIGHTEST STEAM ENGINE.

Condensed from a paper in the "Popular Science Review," by Fred. W. Brearey, Honorary Secretary to the Aëronautical Society of Great Britain.

In its normal state, the air is inapplicable as a power, but it is capable of becoming an overwhelming power, either by natural or artificial causes, as in the whirlwind and tornado or by rushing forcibly through it, as would be exemplified were the sails of a windmill rotated rapidly against it. Thus the bird may create for itself in a calm, by the agitation of its wing-surface, the power which supports and prolongs its flight in a horizontal or ascending line ; but is also capable, in the calm of a sultry summer's day, by the mere momentum of its own weight, of gliding for an immense distance upon an unyielding plane, thus converting the inert air into a fulcrum or support. In such a case, two only of the three requisites for successful flight are brought into action, viz, surface and weight, the third, force, being held in reserve for extraordinary occasions.

There can be no question in dispute, as to the possibility of so manipulating and inclining the surface of a descending body, as to prolong the gliding motion, and convert it into one obedient in some degree to the will of the operator. When the two antagonistic forces, gravity and atmospheric resistance, are brought into operation, the result is a course, arrested and diverted in some direction, either by what we call accident, or design. Hitherto, as in the case of the parachute, accidental circumstances have alone determined the deviation. It has been the great desire of man for ages to supply, either in his own person, or by the aid of apparatus, or by self-acting machinery, the third requirement for flight, viz, force, which may enable him to impel a plane surface at the proper angle of inclination against the air, and thus to nullify the effect of gravity.

Necessarily, the relative proportion of sustaining surface to weight, and of power to uphold and propel that weight, have occupied much attention. Considerable misconception has existed upon these two points, and to this is mainly due the tardy progress of the science of aëronautics. In England, the subject has really never engaged the attention of scientific men, except under the form of aërostation, in the earlier years of its discovery. There have ever been persistent believers and experimenters, and in the influential association which has been organized under the name of the Aëronautical Society of Great Britain, embracing amongst its supporters some of the first scentific men of the day, with the Duke of Argyll as President, the subject of aëronautics has been elevated into a science.

In a paper by M. De Lucy of Paris, there is detailed the result of actual experiments made by the author, with a view of determining the extent of wing surface to the weight to be sustained, and of the force requisite to raise and impel in horizontal flight. The author asserts, that there is an unchangeable law, to which he has never found any exception, amongst the considerable number of birds and insects, whose weight and measurements he has taken, viz, that the smaller and lighter the winged animal is, the greater is the comparative surface. Thus in comparing insects with one another ; the gnat, which weighs 460 times less than the stag-beetle has 14 times greater relative surface. The lady-bird which weighs 150 times less than the stag-beetle, possesses 5 times more relative surface, etc. It is the same with birds. The sparrow which weighs about ten times less than the pigeon, has twice as much relative surface. The pigeon which weighs about eight times less than the stork, has twice as much relative surface. The sparrow which weighs 339 less than the Australian crane, possessess seven times more relative surface, etc. If we now compare the insects and the birds, the gradation will become even much more striking. The gnat, for example, which weighs 97,000 times less than the pigeon, has 40 times more relative surface ; it weighs 3,000,000 times less than the crane of Australia, and possesses relatively 140 times more surface than this latter, which is the heaviest bird the author had weighed, and it was that which had the smallest amount of surface, the weight being 20 lbs. 15 oz. $2\frac{1}{4}$ dr. avoirdupois, and the surface (referred to the kilogramme 2 lbs. 3.27 oz.) 139 square inches ; yet of all traveling birds, they undertake the longest and most remote journeys, and, with the exception of the eagle, elevate themselves highest, and maintain flight the longest.

M. de Lucy remarks, that if the law of surface in inverse ratio to weight be regarded, the cause of all the errors which have been committed will be readily understood; for a mathematician who should select as his type an excellent bird of flight such as the swallow, by ascertaining its weight and surface, will apportion nearly one meter or 1,550 sq. in. to the kilogramme, and consequently 75 meters for a man of 75 kilogrammes, that is to say, about 165 lbs. would require a surface of 116,250 sq. in. Should he select the pigeon, he will arrive at a result quite different, because the pigeon being heavier than the swallow has a surface relatively smaller. According to this type, he would arrive at the conclusion that only 20 meters of surface or 31,000 sq. in. would be requisite for a man of the same weight. The example of the crane of Australia, would give to a man a surface of no more than 10,850 sq. in. Again, should he select a type amongst insects, for example the blue dragon-fly whose flight is so rapid, he would discover the weight to be rather more than $\frac{1}{2}$ grain, and surface nearly $\frac{2}{5}$ of a square inch, which referred to the selected standard of comparison would give 9,416 sq. in. and for the man 705,800 sq. in. Were we to determine the amount of sustaining surface requisite for the man from some of the butterfly tribe, whose wings are so prodigiously expanded in comparison with their weight, we should arrive at results so much in excess of these dimensions, that the construction of the apparatus would be impossible.

The author next proceeds to state that "The law of surface, in inverse ratio to weight, would naturally tend to lead us to this conclusion—viz: that the heaviest-winged animal, having the least surface, ought in return to possess the greatest force." But he proceeds to disprove this assumption, by showing, that the muscular force of insects is much greater than that of birds, and he adduces various well-known instances. Upon the supposition that his facts, and the theory founded on them, are correct, it will be a fair hypothesis to assume that where large wing-surface is given to insects, the provision is accompanied by the relative power to control it, in compensation for absence of weight, which we have seen is during descent a power of itself, and is taken advantage of by some birds, in gliding, or soaring against a breeze. For such purposes, weight is a necessity, and therefore we never see any similar method of flight in the winged insect tribe.

The first recorded and scientifically based attempt to connect plane surface and weight, in relative proportion to one another, was that of which all the world was cognizant in 1842, patented by Henson—a plan resulting from conversation between Henson and Stringfellow. "The amount of canvas or oiled silk necessary for buoying up the machine, was stated to be equal to one square foot for each half pound weight, the whole apparatus weighing about 3,000 lbs., and the area of surface spread out to support it, 4,500 square feet in the two wings, and 1,500 in the tail, making altogether 6,000 square feet." But this machine was never constructed; for after two abortive attempts to manufacture models, which should represent the dimensions before-named, the two inventors commenced their experiments under a variety of forms. Mr. Stringfellow frequently availed himself of the express train, taking with him an arrangement for testing the resistance of different angles against the air, at high speed, and he states that those experiments only tended to prove, that any guess-work was better than the calculations hitherto made by writers on the subject. In 1844, they commenced the construction of a model which measured twenty feet from tip to tip of wing, by three and a half feet wide, giving seventy feet of sustaining surface in the wings, and about ten more in the tail. The weight was from twenty-five to twenty-eight pounds.

An inclined plane was constructed, down which the machine was to glide, and it was so arranged that the power should be maintained by a steam engine, working two four-bladed propellers, each three feet in diameter, at a rate of 300 revolutions per minute. For seven weeks the two experimenters continued their labors. In the language of Mr. Stringfellow: "The machine was saturated with wet from a deposit of dew, so that anything like a trial was impossible by night. I did not consider we could get the silk tight and rigid enough. Indeed, the framework altogether was too weak. The steam engine was the best part. Our want of success was not for want of power or sustaining surface, but for want of proper adaptation of the means to the end of the various parts." Many trials by day down inclined wide rails showed a faulty construction, and its lightness proved an obstacle to its successfully contending with the ground currents.

Shortly after this, Mr. Henson left for America, and Mr. Stringfellow, far from discouraged, renewed alone his experiments. In 1846 he commenced a smaller model for indoor trial, and, although very imperfect, it was the most successful of his attempts. The sustaining planes were much like the wings of a bird. They were ten feet from tip to tip, feathered at the back edge, and curved a little on the under side. The plane was two feet across at its widest part; sustaining surface, seventeen square feet; and the propellers were sixteen inches in diameter, with four blades occupying three-fourths of the area of circumference, set at an angle of sixty degrees. The cylinder of the steam engine was three-fourths of an inch in diameter; length of stroke, two inches; bevel gear on crank shaft, giving three revolutions of the propellers to one stroke of the engine. The weight of the entire model and engine was six pounds, and with water and fuel, it did not exceed six and a half pounds.

The room which he had available for experiments did not measure above twenty-two yards in length, and was rather contracted in height, so that he was obliged to keep his starting wires very low. He found, however, upon setting his engine in motion, that in one-third the length of its run upon the extended wire, the machine was enabled to sustain itself; and upon its reaching the point of self-detachment, it gradually rose, until it reached the further end of the room, where there was canvas fixed to receive it. It frequently, during these experiments, rose after leaving the wire, as much as one in seven. He afterwards experimented with greater success at the Cremorne Gardens. Having now *demonstrated the practicability of making a steam-engine fly*, and finding nothing but a pecuniary loss, and little honor, this experimenter rested for a long time, satisfied with what he had effected.

In a paper read by Mr. F. H. Wenham, at the Society of Arts, on the occasion of a meeting of the Aëronautical Society, there occurred the following observation: "Having remarked how thin a stratum of air is displaced beneath the wings of a bird in rapid flight, it follows, that in order to obtain the necessary *length* of plane for supporting heavy weights, the surfaces may be superposed, or placed in parallel rows, with an interval between them. A dozen pelicans may fly one above the other, without mutual impediment, as if framed together; and it is thus shown, how two hundredweight may be supported in a transverse distance of only ten feet." Mr. Stringfellow having been again called out by the Aëronautical Society, eagerly grasped this idea and set about constructing the model which he exhibited at the Crystal Palace in 1868. This model contained in its three planes, a sustaining surface of twenty-eight square feet, besides the tail. Its weight, with engine, boiler, fuel and water, was under twelve pounds. It possessed in its steam-engine one third of the power of a horse, and its weight was only that of a goose. It will be seen, therefore, that the sustaining surface was more than two feet to the pound, always supposing that the system of superposing the planes, was efficiently represented in so small a model, which may reasonably be doubted. This proportion of weight to surface is more than double that which is generally allowed to be necessary. The necessity, however, for providing even for as little as one pound for every square foot, would not exist if a certain speed could be maintained.

It has been observed by several reporters for the press that the model showed a decided tendency to an upward course during its hundred yards run at the Crystal Palace, but upon farther trial, when freed from its support it descended an incline with apparent lightness, until caught in the canvas, but the general impression conveyed was this—that had there been sufficient fall, it would have recovered itself, and proceeded onwards. Subsequently, Mr. Stringfellow lengthened the propellers, and added nine feet to the central plane, which, with other alterations, decidedly deteriorated its aërial capabilities. He is now engaged in experimenting with a view of ultimately constructing a large machine that would be sufficient to carry a person to guide and conduct it. On this scale he would avoid many difficulties which are inseparable from small models.

As Mr. Stringfellow gained the prize of £100 for "*the lighest steam-engine in proportion to its power*," and as the engine which propelled the model at the Crystal Palace differed from that but in dimensions, we append a description of the engine, which was given in the report upon Exhibition published by the Aëronautical Society: "The steam engine does not differ from an ordinary one, except in the precautions to ensure lightness. The two-inch cylinder is of very thin brass tube; the covers, flanges and glands are also as light as can be made, consistently with strength; the ports and passages are in one separate piece, screwed on; the piston-rod passes through each end of the cylinder, and by means of long connecting rods, works in opposite directions two cranks, fitted to the axes of two four-bladed screws, three feet in diameter; two light bars extend from the crank-shaft down each side of the cylinder: these sustain the thrust of the piston, and a framing is thus almost dispensed with. The boiler consists of a number of inverted cones, made of very thin sheet copper, with the joints soldered with silver solder. Each cone is closed with a hemispherical cap. The cones are placed in parallel rows; the bottom ends, or apexes, of the series are all connected together by water-tubes; and from the hemispherical tops a small steam pipe conveys the steam away to a cylindrical chamber above the system: this is set in the smoke-box, and serves as a super-heater, and the steam is quite dried therein. The cones are not liable to prime, as the water surface for the escape of the steam is extensive, and the steam rises clear from the generating surfaces. The fire space between the bases being large and free, this form of boiler is particularly well adapted for burning liquid fuels. The cylinder is two inches in diameter, stroke three inches, boiler pressure 100 lbs. per square inch. The engine makes 300 revolutions per minute. In three minutes after lighting the fuel, the pressure was 30 lbs.; in five minutes, 50 lbs.; and in seven minutes its full working pressure of 100 lbs., driving two four-bladed screw propellers, three feet in diameter, at 300 revolutions per minute.

In an article entitled "Swimming or Flying," contributed to the "Times," (April 9, 1868,) the author comments upon the possibility of man's sustaining himself by his own muscular exertion, and especially refers to Mr. Charles Spencer's assertion that he could not only effect this feat, but that he could sustain flight for several yards. Mr. Spencer constructed an apparatus, and by its means he avers that he has proved, that 110 square feet properly disposed, is sufficient to sustain 158 lbs. weight. With such an apparatus, composed of plane and wings, he states, that running down a small incline in the open air, and jumping from the ground, he has by the action of the wings, sustained flight to the extent of 120 feet. The framework of this apparatus, was a marvel of lightness and strength, composed of steel umbrella wires and wicker-work. Length of tail, 18 ft.; width at the end, 8 ft.; depth of keel at the end, 4 ft.; weight of tail, 15 lbs.; area of tail, 72 sq. ft. Length of wing, 7 ft.; width at the widest part, 4 feet; area, 15 sq. ft.; weight, $1\frac{1}{2}$ lb.; weight of the whole—tail 15 lbs.; wings, 3 lbs. = 18 lbs.; weight of himself, 10 stone, and sustaining surface, 110 sq. ft.; total weight of himself and apparatus, 158 lbs.; making not quite $1\frac{1}{2}$ lb. to the square foot. Owing to the wicker-work—which is made to fit tight round the body—causing pain, and otherwise obstructing his movements, he was unable to satisfy the curiosity of the public, and he is now reconstructing that portion, and substituting a stronger material for the covering. According to De Lucy's theory of surface in inverse ratio to weight, the sustaining surface, instead of being 110 square feet, need only have been about 31 square feet, always supposing that the surface was effectively disposed, which in Spencer's apparatus may be very properly questioned.

We come now to the description of another—Gibson's machine. Dissimilar to either of the former inventions, which respectively consisted of plane—and plane with wings—this was expected to obey the action of the wings alone. The mechanical action at the command of the operator was intended to be controlled by the downward pressure of each leg alternately, assisted by the arms. The machine therefore consisted of a framework, to which were attached four wings, so that by pressure upon one treadle, two flew up feathered, and two descended with an impact upon the air.

In a previously constructed apparatus provided with two wings only, Gibson states that a man weighing $10\frac{1}{2}$ stone repeatedly raised himself from the ground from 12 to 18 inches, but that he could not sustain himself, because the wings being so heavy, he was not able to repeat the stroke. Each wing was 12 feet long, $1\frac{1}{2}$ feet across at the wider part, and 1 foot at the narrower; surface of both wings 37 square feet; weight of each wing, 10 lbs.; frame and rods, 21 lbs.; weight of man, $10\frac{1}{2}$ stone; giving about 5 lbs. to each foot of sustaining surface, a condition which severely tests the theory of inverse proportion of surface to weight. The four-winged contrivance sent to the Crystal Palace was found to be too heavy for trial, but the inventor's enthusiasm seems to be quite equal to the construction of another and lighter apparatus for further exhibition. It must be remarked, as an interesting feature in Gibson's apparatus, that the total weight of the man and apparatus, as compared with the surface, gives on De Lucy's theory, about 38 square feet as the proper sustaining surface, or one foot more than it possesses—taking for our calculations, the Australian crane, and the theory of inverse proportion with its margin of from eight to ten times.

Experiments can alone determine the true path to success, and it is encouraging to find that these are now aiding in the determination of the question. It is possible that we may shortly witness some more advanced attempts, and should they prove to be failures in the practical solution of the problem, it will perhaps be remembered that previous failures having led to increased knowledge, so future success may result from their repetition.

IMPROVED GAS-HEATING FURNACE.

ESTIMATE OF THE QUANTITY OF FUEL REQUIRED FOR CAST STEEL, WITH THE SIEMENS FURNACE, AND BY THE NEW PROCESS OF PARTIAL ELIMINATION OF NITROGEN, OF M. CH. SCHINTZ, OF STRASBOURG.

Translated from "Le Génie Industriel."

We announced in our last number the appearance of a work of M. Schintz, on the High Furnace. Before giving an analysis of it, as we promised, we believe our readers will be interested in the following analysis upon a kindred subject, which M. Schintz has kindly communicated.

In the "Oestreichichen Zeitschrift für Bergüttenmanner," No. 26, 1868, M. Kupelwieser, Professor in the School of Mines of Leoben, showed that the expense of fuel in the production of steel, by the Martin process, does not greatly exceed that by the Bessemer. This is surprising, in view of the fact that the intense heat by the latter process is produced by the small percentage of carbon in the gray metal, while in the Martin process, as at present conducted, the operation lasts seven or eight hours, and consumes at least 1.5 kilogrammes of lignite for every kil. of steel produced. Although the consumption by the latter process is so great, the small ultimate difference between the two is due to the fact that for the Bessemer, gray iron is used, and for the Martin, white iron, and the production of the latter, in the high furnace, requires but one-half to one-third the quantity of coal necessary for the former.

I have found the computations of M. Kupelwieser quite accurate, though I by no means agree with him when he undertakes to show that the regenerating furnace of M. Siemens is preferable to all others for the Martin process; for it is easy to demonstrate the reverse. I have before me the plan of a reheating furnace, on the Siemens plan, which ought to consume pretty nearly as much fuel as a cast steel furnace; the only difference being that the latter is only about half as long. A charge for the steel furnace is composed of

.888 kil. white pig, .664 kil. puddle bar and crude steel,	} 1.552 kil. = .21555 c. meters of casting.
.47 kil. ore, . . .	pure and rich, which is decomposed into $F\ e\ O$ and $C\ O$—. Volume of the $C\ O$ 1.5 cubic meters.

Assuming that the melted metal is .15 m. thick, the surface will be $\frac{.21555}{.15} = 1.437$ sq. met., and allowing .5 m. for the breadth, the length will be $\frac{1.437}{.5} = 2.8$ met. But in the Siemens furnace we must add the bridges which hold the metal, the flues which conduct the gas, and the air and the flues at the other end which lead off the products of combustion. All this augments the length of the melting furnace, and gives us, instead of 2.8 m., a length of 4.2 m., and the exterior surface of the arch and side walls becomes 10 sq. m., while without these necessary accessories this surface would be but 3.42 sq m. Now, making all due allowance for what takes place in the regenerators themselves, their use is a source of great loss of heat, for we have just shown that the loss of heat by transmission is excessive, compared with the useful effect. The transmission for a unit of surface, per hour, is

$$t' = \frac{T - t''}{1 + Q\frac{e}{c}} + t''\,Q.$$

T being the temperature of the furnace; t'' that of the atmosphere

$$Q = \frac{S\ m\left(\frac{t}{a-1}\right) a\ l + L\ u\ t^{6}}{t}$$ (formula of Dulong).

$S = 3.62$, $L = 1.988 = 20°$, $e = .2$, $c = 0.8$ at least, $e =$ thickness of walls, $C =$ the conductibility of the materials of which the walls are composed.

M. Ed. Becquerel has found that the melting point of decarburized iron is between 1,350° and 1,400° Cent. There is no probability that the temperature of the furnace exceeds 1,400° C., otherwise the operation would not last seven or eight hours. Supposing, then, that $T = 1{,}400°$ and $t'' = 20°$, the theoretical transmission is $\frac{1{,}400 - 20}{1 + Q{:}\frac{2}{8}} + 20\ Q = 4{,}892$ calories ($Q = 17.92$). My own researches have shown that the actual transmission of heat is from three to thirteen times greater (according to the temperature) than the theoretical transmission, for the surrounding air being always in movement, and becoming warm, carries off great quantities of heat. The effective transmission in this case cannot fall short of 134,892 = 63,596 calories per sq. met. per hour. For 10.24 sq. m. this becomes 651,223 calories. But we must remember that the value of L in the formula of Dulong is less for a horizontal than for a vertical surface. We must, therefore, deduct one-third upon two-thirds of the calculated transmission, which amounts to 71,501. Deducting this 651,223 — 71,501 = 579,722 calories.

To melt one kil. of decarburized iron the heat consumed is $1{,}400 \times .16585$ (.16585 being the specific heat of iron at 1,400°) = 232 calories. Latent heat of fusion = 160 + (.16585 — .11379) 1,400 = 233 calories. Total heat consumed in melting one kil. of iron, 465 cal., and for 1,552 kil., the entire charge $465 \times 1{,}552 = 721{,}680$, and per hour, allowing eight hours for the operation, $\frac{721{,}680}{8} = 90{,}210$ cal., which, added to the transmission above calculated, gives for the number of calories employed in the furnace of fusion, 669,932.

The fuel employed at Leoben was lignite, of which the calorific power is 5,419 calories per kil. for a perfect combustion, and on the supposition that the gas arrives in the furnace at the temperature it gets in the generator. It is known that in the Siemens furnace it is necessary to cool the gas and condense the hydro-carbon vapors, because if they get into the regenerator they are decomposed there, and give off a deposit of carbon which obstructs the flues; but as the heat so lost is restored by the regenerator itself, we may consider the gas as being in the same condition as if it had not been cooled. Hence, the pyrometric equivalent of the lignite, for a furnace temperature of 1,400°, is $5{,}419 - 1{,}400 \times 2.15525 = 2{,}402$ calories, and the quantity carried off per kil. of lignite = 3,017 calories. Dividing the consumption of heat in the furnace by the pyrometric equivalent, we obtain $\frac{669{,}932}{2{,}402} = 279$ kil. of lignite necessary for this consumption. But the actual expense is 291 kil., and thus there remains an excess of 291 — 279 = 12 kil., showing that a portion of the gas is not burned in the furnace, but in the regenerator. The same thing may be seen taking place in the largest glass furnaces, which are six to eight meters long, and I have noticed that there is always some flame at the end of the fire circuit, which proves that the gas is burned gradually. The result is, that in the Siemens system the gas and air are not thoroughly enough in contact to make a perfect combustion. If, now, the length of fire circuit, for accomplishing approximately the same result, is only four meters, it need not surprise anybody if the combustion is completed in the regenerator. The following are the quantities of heat which the regenerator receives per hour:

279 kil. lig. at 3,017 = 841,733 } = 906,771
12 " " 5,419 = 65,028 } calories.

The capacity of the four chambers of the regenerator is 42,336 cubic met., of which $\frac{1}{3}$ is of solid fire-brick, = 14,112 cubic met. at 1.9 [specific gravity] = 26,812 kil., and the capacity for heat = $26{,}812 \times .24 = 6{,}435$ calories.

The maximum of heat in the regenerator, when the products of combustion cease to pass it, is

Entrance temp. $= \frac{906{,}771}{291 .\ 2.15525} = 1{,}446°$.

Exit temp., ... 300°.

Mean, ... 873°.

Maximum capacity $873 \times 6{,}435 = 5{,}617{,}755$ cal.

It is at the minimum, just after the air and gas have ceased to pass, and hence it is minus the heat introduced per hour, which is, as above, 906,771, making 5,617,755 — 906,771 = 4,710,984 calories, and the mean temperature of this regenerator is not above $\frac{4{,}710{,}984}{6{,}435} = 732°$.

The exterior surface of the regenerator

measures 46.02 sq. met., the thickness of the walls is $e = .3$, their conducting power at least $.6 = c$. Hence the mean temperature regulating the transmission is $\frac{873+732}{2} = 802°$, and the theoretic transmission becomes $\frac{802-20}{1+Q:\frac{3}{6}} + 20\ Q = 1{,}537$ cal.

The actual transmission is 7,753 calories, and the total

		Calories.
Transmission	$= 46.2 \times 7{,}753 =$	358,188
The loss by escape,	$300 \times 291 \times 2.15815 =$	188,100
Useful effect, ...		360,483
Total heat equal to that introduced, ...		906,771

The quantity of heat lost by the gas in cooling is 303,804 calories. Hence all the gain we get from the regenerator is 56,679 calories—just enough to raise the temperature of the air to 289°.

These calculations are the results of a system of long continued and very careful experiments, and are perfectly in harmony with the facts, for if the temperature of the furnace is higher than the melting point of the metal, the operation would be complete in much less time than seven to eight hours.

I have proved, by the formula of Cauchy, that supposing the metal to be penetrated with a volume of carbonic oxide equal to its own, while the bed of coal is $2 \times .15$ met., the conductibility will be such that in a few minutes the mass will take the temperature of the furnace. Now, to produce steel much more cheaply than by the Bessemer process (which leaves a great deal to be dedesired on the score of certainty of quality in the product), we should have to devise a method of heating which would admit of a higher temperature. It need not necessarily be very much higher—in fact an addition of 100° would probably be sufficient to reduce the length of the operation one half, and hence, even supposing the quantity of fuel burned per hour to be the same, there would still be an economy of one-half the fuel, of labor, interest on capital, etc. We shall proceed then to show that it is practicable to increase the heat of the furnace at a smaller expense of fuel.

This method consists essentially in the production of a gas which contains a smaller proportion of nitrogen than is usual in processes now employed.

To produce this gas we may decompose by heat carbonate of lime, and pass the carbonic acid given off over coal dust or some substance containing carbon. This will give us pure carbonic oxide. By burning this with the quantity of air necessary to reproduce the carbonic acid, and effecting this operation within a combustible solid, which will again reduce the $C\,O_2$ to $C\,O$, this last product will be mixed with only one-half the volume of nitrogen which ordinarily accompanies the gas produced by combustion. The pure oxide of carbon will have, on leaving the chamber in which it is produced, a temperature of 1,000°. For every kil. of carbon which it contains it will yield 2,400 calories, to which we must add $1{,}000 \times .2479 \times 2\ 333 = 578$ cal. If the air used in the combustion is introduced at 300°, it adds $300 \times .2377 \times 5.7515 = 410$ cal., which, added to the foregoing, is 3,388 cal. On the other hand, the reduction of the carbonic acid produced, absorbes 2,400 cal., and deducting this the quantity of heat contained by the gas will be 988 cal. This gas is composed of

4.6666 k. $C\,O$ whose spec. heat = 1.1568 }
3.4418 k. N whose spec. heat = .8392 } 1.9966

The temperature of the mixture will therefore be $\frac{988}{1.9966} = 495°$. The burning of 4.6666 k. of $C\,O$ in the furnace will yield

		Calories.
4.6666×2400, ...	=	11,200
The gas brings with it, . .	=	988
The air at 300° brings $11.5030 \times 300 \times .2377$, ...	=	820
Total, ...		13,008

The products are

7.3333 k. $C\,O_2$ spec. heat, 1,587 }
10.5458 k. spec. heat, 2,573 } 4,160

and the initial temperature is $\frac{13{,}008}{4{,}160} = C$ .3127° C.

For 1 kil. of lignite (allowing that $\frac{1}{3}$ kil. of carbon is absorbed by the carbonic acid given off by the carbonate of lime, which contains 0.20565 k.) there will be required

1.7136 k. carb. lime, . . . 20,563 cal.
3333 } 1.0000 lignite, . . { 20,563 "
6667 } { 41,126 "

and we have $.41126\ C = 95061\ C\ O$, which requires $.54855\ O + 1.8171\ N = 2.236545$ kil. of air, and becomes 1.50796 k. $C\,O_2$ +

1.8171 N. To reduce again this $C\,O_2$ to $C\,O$, will take .41126 C. contained in 0.6667 k. of lignite, —0.6667 k. lignite containing 0.41126 k. calories, 0.17994 elements of water, 0.01346 free hydrogen. So we shall have in the gas produced

kil.		kil.	
1.91992 $C\,O$,	which requires	1.0967 O	
.01346 H,	" "	.10768 O	= 3.9908 N
.17994 $H\,O$,	" "	1.20438 O	k.
1.8171 N,	" "	5.19018 air	=5.1918 air

The gas produced by C and $Ca\,O$, $C\,O_2$, receives in the chamber where it is produced the temperature of 1000°, and consequently brings 1000 × .95961 × .2479 = 238 cal.

The air to be burned with it, 300×2.36545×.2377, . .	= 168 "
Total,.	406 "

The production and absorption of heat by the reduction cancelling each other, need not be carried forward in the account, but there will be .17994 $H\,O$ to evaporate, which will take .17994 × 536.67 =96 calories to be deducted, leaving in the gas 310 cal.

The following is the composition and specific heat of the gas:

k.				
1.91922 $C\,O$	× .2479	= .4757		
.01346 H	× 3.4046	= .0458		
.17994 $H\,O$	× .475	= .0855		1.0504
1.8171 N	.244	= .4434		

Hence the temp. will be $\frac{310}{1.0504} = 295°$ C.

By burning this gas in the furnace we produce

k.	cal.	cal.	
1.91922 $C\,O$ at	2400	= 4,606	
.01346 H at	34000	= 457	5743 cal.
5.19518 hot air at	300	= 370	
Brought in by the gas		310	

The specific heat of the product is

k.			
3.01592 $C\,O_2$	0.2164 =	.65262	
.30108 $H\,O$	.475 =	.14301	2.21273
5.8079 N	244 =	1.41710	

The initial temperature $= \frac{5743}{2.21173} = 2596°$ C. The pyrometric equivalents for the following temperatures will be

For	1400°	1450°	1500	1550	
Pyr. Eq.	2645	2535	2424	2314	cal.
Heat passing off,	3098	3208	3319	3429	cal.

Hence it appears that the same weight and kind of fuel will produce a furnace temperature of 1500°, while without the elimination of nitrogen it would give but 1400°. It now remains to see whether the heat passing off from the furnace will be sufficient to decompose the carbonate of lime, and to reduce the carbonic acid formed to carbonic oxide.

For the same dimensions of the furnace proper the area of the arch and walls reduces to 3.42 sq. met., because we no longer need the entrance and exit flues, nor the bridges for holding the melted metal. If we suppose the times corresponding to temperatures to be as follows,

Hours,	8	$6\frac{1}{2}$	5	$4\frac{1}{2}$
Temp.,	1400	1450	1500	1550

we shall not have exaggerated the advantage, which gives us as useful effect, per hour,

$$\frac{721680}{8} = 90210$$

$$\frac{721680}{6.5} = 111028$$

$$\frac{721680}{5} = 144336$$

$$\frac{721680}{4.5} = 162573$$

Observing that this arch is one-half the whole surface, and using the same notation as before, we shall find the actual transmission, per square meter, per hour, to be

				Cal.
	47697	49187	51114	53109
and for 3.42 sq. m.....	163123	168219	174810	181633
Useful effect ..	90210	111028	144336	162573
Total heat ..	253358	279247	319146	344206

These figures, divided by their pyrometric equivalents, give for the expense of fuel per hour

96 110 132 149 kil. lignite,

and the quantities of heat passing off,

297408 352880 438108 510921 cal.

For 1 kil. lignite we must decompose 1.7136 kil. of carbonate of lime, which requires, in order to be heated to 1000°

1.7136 × .675083 × 1000 = .	1157 cal.
Heat of combination 1.7136×251	430 "
Heat of $C\,O_2$ first formed . . .	1587 "
Heat to reduce it to $C\,O$ . . .	493 "
Total, ...	2080 "

And for the calculated weight of fuel

199680 228800 274560 309920 cal.

Leaving the heat to pass off

97728 124080 165548 201001 cal.

The weight of $Ca\,O\,C\,O_2$ to be decomposed per hour is

164 188 226 255 kil.

and as it takes two hours to effect the operation at 1000°, the volume of it will have to be double,

.246 .285 .338 .382 sq. met.

The height of the chambers being one meter, their length, in order to contain these quantities, must be

.5 .6 .7 .8 met.,

and it will require two chambers in order that one may be working while the other is being charged.

The chambers containing the carbon for reducing the $C\,O_2$, which is given off by the lime, should be as large as practicable, in order to avoid the necessity for frequent charging, and allowing for height one meter, and breadth .25 met., we propose to give the lengths

1.2 1.5 1.4 1.5 met.,

and the following number of the chambers,

3 3 4 4

We have seen that the gas produced in the generators receives the temperature only of 295°, which is not enough to effect a perfect reduction, but by surrounding the generators with products of combustion at 1000°, we can effect a perfect, which is a matter of great importance. By making two generators .8 met. long, .8 high, and .45 wide, we can arrange them in the furnace with the necessary chambers, in such a manner that the latter will present a minimum surface of 15.97 sq. met., and a maximum of 20.66 sq. met., and allowing a thickness of wall of .5 met. $=e$, and a conductibility $c=.6$.

Then the theoretic transmission, per sq. met., per hour, will be

$$\frac{1000^\circ - 20}{1 + Q:\frac{5}{6}} + 20 \times 10.197,$$

and the actual transmission four or five times greater, ... = 5722 cal.

Total maximum transmission 2066×5722 . . } = 118216 "

Total minimum transmission 1597×5722 . . } = 91380 "

while the quantities at our disposal are, maximum, 201001 cal.; min. 97728 cal.

Hence the quantity of heat passing out of the fusion furnace is more than sufficient for the production of the carbonic oxide.

If the assumptions we have made as to the relative time of fusion are correct, which is very probable, the consumption of fuel for one kil. of steel will be

$$\frac{96 \times 8}{1552} = 0.495 \text{ k.} \quad \frac{110 \times 6.5}{1552} = 0.461 \text{ k.}$$

$$\frac{132 \times 5.5}{1552} = 0.425 \text{ k.} \quad \frac{149 \times 4.5}{1552} = 0.431 \text{ k.}$$

lignite, while by the furnace at Leoben it is

$$\frac{291 \times 8}{1552} = 1.5 \text{ k.}$$

Origin of Force—Weight no Force.—Gravitation, acting in the direct ratio of the mass of bodies, gives us a direct measure of this mass by the weight. As a unit of this weight the pound has been adopted, and the expression of a certain number of pounds affords us, therefore, a tolerably definite notion of the amount of matter with which we have to deal. When, now, by the removal of obstacles, gravitation is allowed to produce motion, this motion, must accelerate as long as gravitation continues to act in the direction in which the body is moving. The motion thus produced by gravitation is called an accelerated motion; but gravitation is not necessarily an accelerating force. It may act as a retarding force, when the body moves in an opposite direction, as, for instance, when a stone is thrown upward. In fact, gravitation may result in an accelerating force, in a retarding force, or (in case there is no opportunity for the body to be brought into motion) in no force at all.

But to return: a body is put in motion by gravitation only; it falls, and there is a force generated, which increases in proportion to the space through which the body falls. This space, again, is proportional to the square of the time that gravitation acts, according to the well-known law of falling bodies. Suppose, now, that this motion, after being produced by gravitation, is totally or partially destroyed by resistance, heat will be produced. Direct experiments have demonstrated this to be a permanent fact. By modifying the circumstances, electricity, light or magnetism may be produced or apparently generated; and we may therefore look upon gravitation as the prime source of all other forces. In the same manner as we cannot destroy the motion of a leaden ball, falling only from the height of a few feet on the floor, without observing a remarkable increase in the temperature, so any cosmical matter, falling toward a center of attraction (the sun), must, at reaching that center, where its motion is destroyed, cause a rise in temperature, of an intensity proportional to the weight of matter, and to its final velocity. When the masses are thousands of millions of tons, and the distance through which they fall thousands of millions of miles, and consequently the velocities enormously great, the resulting rise in temperature must necessarily be far beyond our conception. This is, in fact, the modern modification of the celebrated nebular theory of La Place.

When gravitation is prevented from producing motion, no equivalent of heat can be produced by the destruction of motion, as there is no motion; and, as all force can be expressed by an equivalent number of units of heat (one unit of heat being 770 units of force or foot-pounds), it becomes at once self-evident that the simple weight of bodies, as it can not be expressed in terms of heat, can not and must not be considered as expressing anything like a force. It must, therefore, not be used in a sense conveying the thought that a ponderable body of a certain weight can represent a force. The defective but common use of language, in mentioning forces of so many pounds, hundred-weights or tons, should give way to the more accurate ideas of modern science. Reform in this direction will be much easier than at first appears.—*American Journal of Mining.*

Hollow vs. Solid Shafting.—Hollow shafting, where large diameter is not objectionable, has long been in use, made generally of cast iron, and frequently used as a drum or continuous pulley for the reception of belts. Such a shaft was used in the "pistol shop" of Colt's factory before the destruction of the building by fire about four years ago, and a similar line may now be in use in the reconstructed building. This shaft was five hundred feet long and fifteen inches diameter, made of hollow cast-iron cylinders, connected with each other by a solid shaft or bearing at each end, resting in a box as a journal. The result was an almost continuous drum, of five hundred feet in length, from which belts led to the counter shafts of the machines, the speed of each machine being regulated by the diameter of the pulleys on the counter shafts. We have heard also of wrought iron pipes of only two inches diameter being used as shafting successfully.

Tredgold says that a round tube whose internal and external diameters are as seven to ten, respectively, has twice the lateral strength of a solid cylinder containing the same amount of material. A cylinder (solid) of cast iron, five inches diameter, has a transverse strength of 21,104 pounds, while one of eight inches diameter, containing the same cross sectional area of metal, has a transverse strength of no less than 45,416 pounds.

These facts would seem to show plainly the possibility of reducing the weight, materially, of shafting, without a diminution of its strength. The weight of shafting is a mass, the inertia of which must be overcome by the driving power, and in some cases the amount of power, otherwise useful, that is thus absorbed, is not less than twenty per cent. If by the use of lighter shafting this could be reduced only five per cent, the saving would be worth an effort. Shafting must be of sufficient diameter to sustain the weight of pulleys and the strain of belts without springing, but if the requisite stiffness—resistance to torsion and springing—can be obtained by hollow shafts of much less weight, not only is money saved in the first cost (shafting being furnished by the pound), but the continual expense in the absorption of unnecessary power in driving the unnecessary weight would also be prevented. That hollow shafting of wrought iron can be made cheaply is sufficiently apparent when we examine specimens of pipe used for various purposes. And not only would the first cost be less, but the ease of handling, owing to reduction in weight, would lessen the cost of turning, etc. Such shafting could also be easily oiled from the inside, which would seem to be the proper method.—*Scientific American.*

Hartmann's Locomotive Works.—Mr. Richard Hartmann has recently added to his large works at Chemnitz, Saxony, a locomotive erecting shop, with lines for thirty-five engines. This shop is 466 ft. long, and 120 ft. wide. The shop for lathes and machine tools, which has been some three or four years at work, is 450 ft. by 90 ft. Mr. Hartmann now employs 2,300 workmen. They are chiefly employed upon locomotives and machine tools. When the business in textile fabric machinery is fairly prosperous, 500 more workmen are employed.

WIRE ROPE TRANSPORT SYSTEM.

"Mechanics' Magazine."

A novel use of wire ropes has recently been patented and put into practice by Mr. Hodgson, C. E., having for its object the construction of light and cheap ways for the transport of mineral or agricultural produce in localities as yet unprovided with railways. Though a great number of cases exist in Great Britain to which it may be applied with advantage, the chief development of this method of carriage will probably take place in the colonies, and in other countries which stand in urgent need of light lines of some kind to convey their productions to the main arteries of inland communication, or to ports. The system may briefly be defined as a continuous development of the plan now not unusual in India, Australia, and in some mining districts, of bridging over a river or ravine by a single wire rope, by which, carried in a bucket suspended by a pulley, the necessary loads are transmitted from one point to another.

To accomplish the easy passing of the points of support necessary to carry out a continuous line of communication, and to provide for the distribution of the burden and the application of motive power, have been problems of no small difficulty; but, after experiments on a first trial length of half a mile, during the autumn of last year, these practical details were worked out, and a contract was immediately entered into for a line of three miles in length at Bardon Hill quarries, belonging to Messrs. Ellis and Everard, near Leicester, which has recently been completed, for mineral traffic. The practical working of this line was recently tested in the presence of a number of engineers and gentlemen interested in the question, when it was found to work well, and to answer its purpose admirably. This line consists of an endless wire rope, supported on a series of pulleys carried by substantial posts, which are ordinarily about 150 feet apart, but, where necessary, much longer spans are taken, in one case amounting to nearly 600 feet. This rope passes at one of its ends round a Fowler's clip drum, worked by an ordinary portable steam engine, and the rope is thus driven at a speed of from four to six miles an hour. The boxes in which the stone is carried are hung on to the rope at the loading end, the attachment consisting of a pendant of peculiar shape, which maintains the load in perfect equilibrium, and at the same time enables it to pass the supporting pulleys with ease.

Each of these boxes carries 1 cwt. of stone, and the delivery is at the rate of about 200 boxes or ten tons per hour for the three-mile distance. It is almost unnecessary to observe that the proportions of such lines can be varied to any extent to suit the requirements of any particular trade, ranging from 10 tons to 1,000 tons per day.

In the case of lines for heavy traffic, where a series of loads, necessarily not less than 5 cwt. to 10 cwt. each, must be carried, a pair of stationary supporting ropes, with an endless running rope for the motive power, will be employed, but the method of supporting, and the peculiar advantage of crossing almost any nature of country with a goods line without much more engineering work than is necessary for fixing an electric telegraph, without bridges, without embankments, and without masonry, exists equally in both branches of the system. The cost of establishing these lines will vary considerably in proportion to the quantity they are required to carry, but from their peculiar construction their cost will vary very slightly in relation to the nature of the ground which they may traverse.

The most important feature in Mr. Hodgson's invention is his method of passing the points of support. Both in lines like that now in operation, where the rope moves, and in those in which it is proposed to have a standing rope separate from the propeller, the stability of the load is obtained by curving in the frame of the carriage till the centre of gravity comes under the rope. The overhanging of the rope is of course essential in this case. Nothing can be more satisfactory than the working of the present three mile line, which stamps it as a practical invention, and which we hope will lead to its adoption wherever the necessity for such an appliance exists.

Burning Liquid Fuel.—Another system has been, after long experiment, put in regular and successful operation by Mr. A. Smith, Stratford, England. The creosote is stored in an underground tank outside the engine-house, from which it is forced up by steam pressure into a reservoir, also outside the engine-house, and to which is attached a float and a graduated scale, by which the consumption of oil is ascertained. A supply pipe from the cistern, with a regulating cock is turned into the tube of each of two

Cornish boilers, 18 ft. long, 5 ft. diameter, with flues 2 ft. 6 in. in diameter. The oil supply pipe projects about 9 in. into the boiler tube, the mouth of which is simply covered by a plate of thin sheet iron, which is raised or lowered to regulate the draft. Into the oil tube is turned a smaller tube carrying the superheated steam, which issues from small apertures at its nozzle. The creosote is thus driven into the furnace with great force, being broken up into the finest spray, and forming a powerful flame, which impinges upon a heap of brick core in the tube which is maintained at a red heat.

From the single jet, steam is easily kept in each of these boilers at a constant pressure of 55 lb. to 60 lb., which is supplied to two engines for driving the machinery. One of these engines is a 10-horse power horizontal; the other, a 30-horse power beam engine. Besides the two boilers already mentioned, there is a third of the same dimensions, in which steam is kept up by the waste and refuse produced in the factory, the steam being used only for heating purposes, and not for the engines. This boiler is always going, and in the morning supplies steam with which the creosote furnaces are started.

The consumption for the two boilers is seven barrels of thirty-six gallons each per day of 12 hours. Taking the cost at the fair price of 1d. per gallon, we have only £1 1s. per day, or 10s. 6s. for each boiler. Mr. Smith's consumption of coal used to be 2½ tons per day—a great contrast in point of expense to his present working. Then, there is a further saving in attendance, a boy being well able to do all that is necessary, whilst there is no clinkering, nor are there any fire-bars to burn out. Altogether, a great economy is realized, and much credit is due to Mr. Smith for the simplicity and efficiency of his invention.—*Mechanic's Magazine.*

THE "ZIRCONIA" LIGHT.—The specification of Messrs. Tessie du Motay & Co. for improvements in oxyhydrogen light, is as follows:

"Zirconia, or oxyd of zirconium, in whatever manner it may be extracted from its ores, can be agglomerated by compression; for example, into sticks, disks, cylinders, or other forms suitable for being exposed to the flame of mixtures of oxygen and hydrogen, without undergoing fusion or other alteration. Of all the known terrous oxyds, it is the only one which remains entirely unaltered when submitted to the action of a blowpipe fed by oxygen and hydrogen, or mixtures of oxygen with gaseous or liquid carbonated hydrogens. Zirconia is also, of all the terrous oxyds, that which, when introduced into an oxyhydrogen flame, develops the most intense and the most fixed light.

"To obtain zirconia in a commercial state I extract it from its native ores by transforming, by the action of chlorine in the presence of coal or charcoal, the silicate of zirconium into double chloride of zirconium and of silicium. The chloride of silicium, which is more volatile than the chloride of zirconium, is separated from the latter by the action of heat; the chloride of zirconium remaining is afterwards converted to the state of oxyd by any of the methods now used in chemistry. The zirconia thus obtained is first calcined, then moistened, and submitted in molds to the action of a press with or without the intervention of agglutinant substances, such as boracic acid or clay. The sticks, cylinders, disks, or other forms thus agglomerated, are brought to a high temperature, and thus receive a kind of tempering or preparing, the effect of which is to increase their density and molecular compactness.

"I can also compress in molds shaped for the purpose a small quantity of zirconium capable of forming a cylinder or piece of little thickness, which may be united by compression in the same mold to other refractory earths, such as magnesia and clay. In this manner I obtain sticks or pieces of which only the part exposed to the action of the flame is of pure zirconia, while the remaining portion which serves as a support to it is composed of a cheap material.

"The property possessed by zirconia of being at once the most infusible, the most unalterable, and the most luminous of all the chemical substances at present known when it is exposed to the action of an oxyhydrogen flame, has never before been discovered, nor has its property of being capable of agglomeration and molding, either separately or mixed, with a small portion of an agglutinant substance."—*Chemical News.*

NAVAL BUREAU OF STEAM ENGINEERING.—The appointment of Mr. King in place of Mr. Isherwood as chief of this department, will close the era of experiments, and inaugurate, it is to be hoped, the safe practice of following good examples.

BUTT-JOINTED BOILERS.

From "Engineering."

For some time past several of our leading locomotive engineers have been in the habit of making the boilers of the engines constructed by them with butt-jointed longitudinal seams, provided with both inside and outside covering strips. No doubt those employing this form of joint, consider it—and very justly—to be a good one ; but, judging from the proportions of the riveting frequently used in connection with it, we believe that in many cases its merits are far from being fully appreciated. Our reasons for this opinion may be explained very briefly. In the case of what we may term an "ordinary" riveted joint—as, for instance, a lap-joint, or a butt-joint with a covering strip on one side only—failing by the shearing of the rivets, this shearing takes place at one point only of the length of the latter, whilst in the event of a butt-joint with covering strips on both sides failing in a similar way, each rivet will be sheared at two points. In other words each rivet is in the last-mentioned joint in a state of "double shear," as it is sometimes called, and therefore exposes twice the resistance that a rivet of the same size would offer in, what we have termed for ditinction, an "ordinary" joint.

Taking this fact into consideration, it follows that in a butt-joint with covering strips on each side of it, the clear space between each pair of rivet holes, should for any given diameter of rivets be twice as great as an "ordinary" joint made with rivets of the same dimensions. Judging, as we have said, from the proportions of the riveted joints of the kind we are considering, which have been actually adopted in practice, the fact just stated has been very generally overlooked, and the rivets have been set at the same pitch as if they were in "single shear" only. Under these circumstances the strength of the rivets is very greatly in excess of that of the length of plate left between the rivet holes, and the joint is, therefore, to some considerable extent, weaker than it would be if proper proportions were adopted.

The actual extent to which the strength of a butt-joint with covering strips on both sides is deteriorated by the adoption of a pitch of rivets, etc., suitable for "ordinary" joints, depends upon other considerations besides the one already mentioned, and how this is the case, we can perhaps best explain by an example. Let us, for instance, suppose a boiler, composed of $\frac{1}{2}$ in. plates, and having butt-joints with covering strips on each side, has been riveted up with $\frac{7}{8}$ in. rivets placed at 2 in. pitch—a proportion very commonly adopted in locomotive work—and let us see how far the strength of the joint can be increased by taking into consideration the fact that the rivets are in "double shear." In doing this we shall preserve the proportion between the areas of the rivets and of the plates between the holes unaltered—not that we consider it the best, however—and we shall suppose the strength of the joint to bear the same proportion to the strength of the solid plate as the length of the plate left between each pair of rivet holes does to the pitch between the centers of those holes. We are quite aware that this latter supposition is not exactly correct; but in comparing several joints with each other the error arising from the adoption of such a standard of comparison is very light. Having made these premises we may now return to our proposed investigation. In the case of the joints with $\frac{7}{8}$ in. rivets placed at 2 in. pitch, the length of plate left between each pair of rivet holes would be $1\frac{1}{8}$ in., or nine-sixteenths of the pitch, and the strength of the joint, measured according to our standard, would be nine-sixteenths, or $56\frac{1}{4}$ per cent. of that of the solid plate. Acting on the consideration that the rivets are in double shear, they might theoretically be moved to a distance of $3\frac{1}{8}$ in. apart from center to center, leaving a space of $2\frac{1}{4}$ in. between the holes, and increasing the strength of the joint, measured, as before, to eighteen-twenty-fifths, or 72 per cent. of the solid plate. If a pitch of $3\frac{1}{8}$ in. was admissible with rivets $\frac{7}{8}$ in. in diameter, we should, as will be seen, then obtain an increase in the strength of the joint equal to $15\frac{3}{4}$ per cent. ; but practically it would be impossible to keep such a joint tight under high-pressure steam, and we therefore come to the conclusion that in place of increasing the pitch it will be advisable to reduce the size of the rivets in order to allow for the latter being in double shear. Let us, for instance, allow the distance between the rivet holes to remain $1\frac{1}{8}$ in. ; and let us employ rivets $\frac{5}{8}$ in. in diameter in place of $\frac{7}{8}$ in., the area of the former being practically half that of the latter. Under these circumstances the pitch will be $1\frac{1}{8} + \frac{5}{8} = 1\frac{3}{4}$ in., and the length of the piece of plate left between each pair of rivet holes will be nine-fourteenths of the pitch, the strength of the joint being thus, according to our standard, nine-fourteenths, or 64.285 per cent of that of the solid plate. The gain over the strength of the joint with $\frac{7}{8}$ in. rivets and 2 in. pitch, is not so great in this instance as when the space between the rivet holes was doubled; but it nevertheless amounts to over 8 per cent—an increase well worth gaining.

We have, we think, said sufficient to explain the principles which we consider should be borne in mind in determining the proportions of riveting for butt-joints with double covering strips, and we need not, therefore, say more about these principles here; but before leaving the subject it may be interesting to point out a deduction to which the facts above stated lead. This deduction is that a properly proportioned single-riveted butt-joint, with any given thickness of plates, and with covering strips on each side, possesses nearly the same strength as a properly proportioned double-riveted lap-joint or butt-joint with a covering strip on one side only. In a properly proportioned double-riveted joint the spaces between the rivet holes (measured along each line of rivets, not zigzag) should be twice as great as that required in single riveted joints having rivets of the same diameter; and we have seen that the same rule applies to single-riveted butt-joints with double covering strips, hence our deduction. In a double-riveted butt-joint, with covering strips on both sides, the strength bears, of course, the same proportion to a single-riveted joint of a similar class that a double-riveted "ordinary" joint does to a single-riveted one.

In concluding this article we may notice one matter connected with riveted joints to which attention is not generally paid, and that is that the proportion which the strength of the joint bears to the solid plate increases with an increase in the diameter of the rivets used. The reason for this is self-evident. The area of rivet increases as the square of the diameter, whereas the length of plate (measured along the line of the joint) removed to make room for the rivet varies as the diameter of the latter only. Thus, supposing that with a certain thickness of plates $\frac{7}{8}$ in. rivets should be placed at a pitch of 2 in., leaving $1\frac{1}{8}$ in. between the holes, then, with the same thickness of plates, $1\frac{3}{4}$ in. rivets (supposing the use of such rivets was admissible) would have to be placed at a pitch of $6\frac{1}{4}$ in., the spaces left between the holes being $4\frac{1}{2}$ in. In the former case $43\frac{3}{4}$ per cent, and in the latter case but 28 per cent of the plates would be removed in forming the rivet holes. This fact shows that it is desirable to in all cases employ in riveted joints the largest diameter of rivets consistent with the fulfilment of other requirements, which practice has shown to be necessary for the attainment of good results.

UNDERGROUND RAILWAYS.

THE DIFFERENT SYSTEMS COMPARED.

The Metropolitan Underground Railway, in London, is the model, from which any departure would be, according to the majority of newspaper reports, presumptuous, unsafe, and not to be considered. We propose to review very briefly the various reports relative to this line, and the opinions of engineers upon it, with a view to give some light to those who take an interest in the subject as it affects New York and other American cities.

The accounts of the success of that work, published here, appear to have emanated from the promoters of various schemes of the kind for New York, and are more favorable than those we find in English engineering journals. For example: in a pamphlet on the Arcade Railway scheme is an extract from the "Evening Post," purporting to be from a report of an eminent American engineer, stating that the work is a great commercial success, and that, though it cost enormously, its dividends have been 12 and 15 per cent. But in the "Railway News" we find that the dividends have been 5 per cent for the first year, $5\frac{1}{2}$ per annum for the next half year, and 7 per cent from that time to the last half yearly dividend, which was at the rate of $5\frac{1}{2}$ per annum. And we find that there has been a serious controversy, in which the directors have been charged with impropriety in making dividends out of capital. A public accountant, Mr. J. P. Lithyre, in a pamphlet, says he was requested, professionally, to examine and report upon the affairs of the company, and that he found that the dividends had been paid mainly out of capital; and that the earnings had not been much over 2 per cent; and that, after closing the capital account, it would be a considerable time before the common stock would receive 3 per cent dividends.

We also see a report that another underground line, in London, from the post-office under Holborn and Oxford street, is projected, to be worked by stationary engines. This indicates that the system of the Metropolitan line does not fully satisfy engineers. "Engineering," though it highly lauds the construction, rolling stock, and working of the Metropolitan, has speculated on improvements which would involve a general reconstruction, or something nearly equivalent.

And there are other systems, which for some years have been discussed, which imply that the Metropolitan is not the best system for city passenger traffic, however fit it may be for the work of the Great Western railway, for which it was built,—being an extension of that line into the heart of the city. Of these proposed systems, that of Mr. P. W. Barlow, has found most favor. Its main features are: 1st. Stations on summits, thirty feet or more above the general level of the line. 2d. Starting the trains from the stations, by very powerful stationary engines, at speed sufficient to send them to the next station. "Engineering" decidedly approves the summits, even for lines worked by locomotives.

Of the plans proposed here, which have been before the Legislature, the first conceived was that brought before the Legislature by Mr. Schuyler, two or three years ago. It was published in 1852, in "Appleton's Mechanics' Magazine," by W——n, (whom we take to be Mr. Worthen, C. E., then attached to the New Haven railway.) Its chief object was, to bring down to the lower part of the city the cars of the New Haven and other country lines; but it also had a secondary object, which was, the city passenger traffic. These objects are the same as those of the London line; and, had the plan been adopted here, probably it would have resulted, as there, in a success of the subordinate object, to such extent as to embarrass the chief object. This plan was, to run a double track railway, in an open cutting between Broadway and Mercer, and other streets in line. Since that time it has become much more difficult, on account of the buildings that have been put up on the rears of the lots; some of which have cost highly, and would greatly enhance the land damages.

Mr. Willson, at first, actively proposed the underground line in New York, after examining fully into the London line, and Mr. A. P. Robinson, C. E., who assisted him, were inclined to propose this route between streets, as much as possible, in open cuttings; but were constrained, by the prospect of enormous land damages, to propose a tunnel under Broadway. And the other underground plans, including the Arcade, have the same feature of being entirely covered, therein differing from the Metropolitan, which is one-third in open cuttings. Messrs. Willson and Robinson propose to ventilate through hollow lamp posts fourteen inches in diameter; and the Arcade is proposed to be ventilated trough the areas of the buildings. We do not believe that either plan of ventilation would render the air wholesome or endurable; and the ventilation through the areas would vitiate the air in the buildings, especially when the windows are open. Neither plan would work so well as that of the Metropolitan; and that excites much complaint, and though its friends are reticent about it in public, they privately admit that it is far from satisfactory. Mr. Johnson, its resident engineer, while in this city, said that the company intended to buy more land to make more openings; and Mr. Dredge, an engineer, who was employed in the construction, informed us that, twenty feet inside the tunnels, the sulphurous odor of the gases was perceptible. And there have been reports in the journals that the health of the employees has been seriously impaired, and several passengers have died on the line. Compared with the open cutting plan, this plan is so inferior that no just amount of land damages can warrant its adoption, if we may judge from the evidence that has come under our notice; and the close tunnel and arcade plans, we believe, would be so much worse that locomotives could not be used in them without repelling the greater part of the people for whose use the work is proposed.

There have been other plans, but as they seem not likely to get moneyed backers, or to be further urged, we have no occasion to seek for their faults, and we know of no merits in them that require us to notice them particularly.

These tunnels would have a different character could they be worked by stationary engines, either on the rope-traction system, or on Barlow's system of impulsion. The rope system has not yet got beyond a very feeble infancy, totally inadequate to the service required in this city. That of Barlow has not been even tried, but it looks well in theory. And, compared with the open cutting plan, for the line between Broadway and Mercer street, we think, in view of the land damages, that Barlow's system is not unlikely to be deemed best, after full consideration of the advantages and disadvantages of both plans.

Barlow represents—in papers read before the Society of Civil Engineers—that the cost of the permanent way will be much lessened if the 42-ton locomotives can be got rid of. It is commonly held that a 4-coupled locomotive of this class injures the track fully as much as twice its weight of carriages; and, as the trains weigh but 80 tons, it follows that more than half the cost of track is by the engines. And this wear is such, that the steel rails have to be renewed in two years. He also represents that the cost of stationary engines would be much less than that of locomotives. And fuel of ordinary quality could be used, instead of the best coke, at double the cost of coal. But the most striking advantage claimed is a considerably higher speed; the stationary engine, drawing by means of a chain, is not limited in power like the locomotive, by liability to slip, but may draw with a force equal to the weight of the train, or greater; whereas, the Metropolitan engines draw with a force not exceeding $\frac{1}{35}$th of the weight of the train and engine. Therefore, in a thirty-fifth of the distance between stations, the stationary engine *may* do as much work as the locomotive can do in the whole distance. And practically, there is no doubt, a stationary engine, working with a chain over two pulleys two hundred feet apart, may start a car or a train with sufficient speed to overcome all the resistances on a line of half a mile, and arrive at the next station at a useful speed of six miles an hour or more. The descent from the summit will help to give the speed; and the ascent to the next summit will help to extinguish it, or will reduce it to a low rate, which the brakes will extinguish without much wear of wheels.

To explain this, let us suppose an excessive undulation of the line. Let the stations be on a level with the sidewalks, so that the passengers need not have the fatigue of going down and up stairs, for twenty feet average as proposed by the tunnel projectors, or seventeen feet as proposed by the arcade people. From these stations let the line descend both ways, at the rate of 1 in 5, for 660 feet. In running down this incline, a car will acquire a speed of 60 miles an hour; it will not only overcome the inertia of its weight, but will also overcome the additional inertia of its wheels and axles as rotating bodies. It will then continue to run, on a level, at 60 miles an hour, until it reaches the next incline, which it will ascend, and arrive at the summit with its speed extinguished. In this case we suppose that it has had no friction or atmospheric resistance, or that these resistances have been overcome by additional power given by the stationary engine. Thus the power required to start is given by gravitation, and taken back by gravitation; and only the power necessary to overcome the resistances of steady running has to be given by the fuel, with a small addition for an excess of speed of six miles an hour, at the end of each run, to save time.

In this mere illustration we have supposed an inclined plane from the summit, and a level to the next incline; but Mr. Barlow proposes a cycloidal curve from summit to summit, as the line of quickest transit.

In the descent, on the inclined plane, the car would run an eighth of a mile at an average speed of thirty miles an hour, and would then run a quarter of a mile at the rate of sixty miles an hour, and then ascend the next incline at an average of thirty miles an hour, making three-quarters of a minute for the half mile. It would then stop three-quarters of a minute—which is the time on the Metropolitan—making one and a half minutes, or three minutes per mile, or an average speed of twenty miles an hour, with stations one-half mile apart. Now "Engineering" computes that $13\frac{3}{4}$ miles an hour is the highest speed practicable on the Metropolitan system, with stations five-eighths of a mile apart. Thus it seems that, without exceeding the maximum speed obtained on English railways—64 to 75 miles an hour—we can get an average speed one-half greater by Barlow's system than we can get by the Metropolitan system, or the modifications of it proposed here.

Comparing the plan of Mr. Schuyler or Mr. Worthen with the tunnel or arcade, we find certain advantages in each. As to speed, it will be greatest where steam can be made most freely, that is, in the cuttings. In the tunnels, on the Metropolitan, the exhaust is turned into a condenser; and not more than one-eighth as much steam is made as is made in the cuttings, where the blast is used. And here, we are confident, the covered ways will prohibit rapid steaming;

and high speed will be attained only in the open cuttings. On the other hand, the covered line will be protected from atmospheric influences, which will render a better construction practicable, and insure greater durability, and get rid of the troubles due to snow and ice, and the cost of removing them. This advantage will be most fully attained in Barlow's plan; for that admits of being entirely housed, covered, and ventilated by the best methods; so that the temperature need not vary beyond the limits of 60° in winter, and 80° in summer. The permanent way may, therefore, be uncommonly permanent; but whether the air will be pure enough for health and comfort is a more doubtful question, which may be answered, more or less confidently, by those who are accustomed to ferry boats, city cars, and other conveyances controlled by men who have got their franchises by favor or otherwise, and use them solely to gain all they can by them. In view of such uncertainties, the open cutting will have numerous advocates.

A station on the Barlow plan will occupy the lower story of nearly the whole rear of a block, for a width of 30 feet; but it may be built over, to any height, by those who supply dark offices to people who are so improvident as to use them. From this block the line will descend so rapidly as to go under other blocks, without disturbing them—the tunnels being driven. The land damages will therefore not much exceed the cost of land for the stations.

The cutting plan will occupy at least 28 feet wide through the back yards. This, or even 40 feet, would really be no loss to the property, for the light-room would be worth more than the buildings that could be put upon it; but this is not the opinion of land owners, and they would demand, and probably get, immense damages—perhaps so much as to render the work unproductive.

There is another plan proposed in a paper on underground railways, read before the Polytechnic Club of the American Institute, by Mr. J. K. Fisher. He proposes to adopt the open cutting plan, locating it where land damages may be less than on the line between Broadway and Mercer street; and to modify it by laying an iron floor instead of rails, and by running steam carriages instead of trains drawn by locomotives. He claims that the carriages can pass each other, so that through carriages can run from end to end without stopping, at full speed; and that the speed may be greater than is attainable on rails, because the flange and cone friction will be avoided. For an up-and-down line 40 feet width would be required; and a guard in the middle, to keep down-carriages from meeting up-carriages, might be adopted; so that collisions could occur only by carriages overtaking others, and the violence would be in proportion to the difference of their speed, and not so great as to cause injury to persons. But when two streets of this kind are built, one may be used for upward, and the other for downward carriages, and the guard may be removed. No pedestrians, and no vehicles but those of the company, to be allowed in these undergrade streets; and all vehicles to run at one rate of speed when on the middle of the street; and to turn out before they stop. The stations may be nearer together than on a railway; and the way-carriages may pass some of them, so as to make fewer stops than trains must make; for example: Carriage A, starting from station 1, may stop at station 3, 5, 7, etc., or at 4, 7, 10, etc.; and carriage B may stop at intermediate stations, so that passengers will be better accommodated, and the speed will be less interrupted than on rails, where every passenger must stop at every station.

Steam carriages are under a cloud, which their friends regard as a cloud of ignorance. They were designed for common roads, and ran upon them to the extent of 50,000 miles or more, before railways got much into use. They were practically approved by several of the best mechanical engineers in the world, who took out patents for improvements in them, and built them. Among these engineers were Maudsley, Field, and Richard Roberts, then at the head of their profession; and Scott Russell and W. A. Summers, then rising to celebrity. But the iron road beat the macadam road; and the locomotive, then called a steam carriage, was supposed to have beaten a lighter steam carriage; but there was powerful opposition to both systems of steam locomotion, against which the common road carriages did not prevail. But about twenty years ago Mr. Brydges Adams proposed steam carriages for railways, and built several, which worked well where the traffic was insufficient for trains. In this country we call them steam cars, and have used them, and still use them, to a considerable extent; and Mr. A. P. Robinson, in his report of a plan for a tunnel railway under Broadway, proposes to adopt them exclusively for that line; and gives engravings of two plans, one by Grice and Long, the other by Mr. Fisher. Take the flanges from their wheels, and add steering gear, and these cars become steam carriages capable of running on any good road. It is supposed that they cannot run profitably on a poor road; but none who have examined them doubt that on iron or even stone floors they can work advantageously.

The question, therefore, is: can light engines, on equally good roads, with stations half a mile apart, work more economically than heavy engines? Can 125 tons be stopped and started as cheaply as ten tons, or less? Mr. Robert Fairlie, C. E., distinguished as the inventor of a new locomotive that is coming much into use, has shown, in a paper read before the Society of Engineers, that the average number of passengers, per train, on the Metropolitan railway is 55. A 10-ton carriage could carry them; and most of the work done in the middle of the day could be done by a few light carriages, leaving the greater number at rest until the movement of people to and from their business. Not only is an unnecessary weight of train used for a small traffic during a great part of the day; but this weight stops and starts at all stations, and cannot do otherwise on this system. Now, on several of our railways, whose maximum speed is not much greater than that on the Metropolitan, careful observations have been made, to find the cost of stopping and starting trains; and they agree, very nearly, that one cent per ton is about the cost. Mr. A. F. Smith, ten years ago, when superintendent of the Hudson River railway, estimated that it cost $1.25 to stop and start a passenger train on that line, on which the trains averaged about 125 tons. Now there is an advantage in favor of a steam carriage, in that it can stop by reversing, and thus avoid wear of its wheels by brakes; and this advantage, where stops are frequent, goes far to balance the greater economy of large engines, so that it is not extravagant to say that one cent per ton would pay for stopping and starting it, and that this considerable part of the working expenses will be lessened in proportion as the weight to be stopped is lessened. But as the through carriages will make but few stops, and the way carriages will stop less than the trains, there will be further reduction on this score. Moreover, if a single carriage breaks down, it will slide along on a floor, and no person will be hurt; but if a locomotive, or a car in a train, break down, all that follows will dash against it, and many may be killed and wounded. Therefore it is necessary to make the railway vehicles excessively strong and heavy for safety. The cars on the Metropolitan weigh sixteen tons empty. Half this weight could be saved were they not subject to be strained by the 42-ton engines, and were there no serious harm to come in case of breaking down.

Considering all these conditions, it is probable that eight times more fuel is consumed on the Metropolitan railway, for an equal number of passengers carried, than would be consumed on an iron floor by steam carriages; and that this consumption of fuel is an approximate index of the wear and tear of engines and carriages.

All these schemes should be tested, so far as practicable, before risking a vast capital upon any of them. The cost of testing the economy of either of the railway plans would be great,—miles must be built and worked for some time before a reliable judgment could be formed. But to test the unsettled questions relative to steam carriages, whether they can be steered securely at the speeds desired, and can work effectively and economically, would involve little cost, for one may be tried on any good macadam road. A very large boiler would be required to test the practicability of steering and handling, at high speed, on a common road; but this would be allowed for in estimating the useful load that may be carried on an iron floor.

In this plan the way traffic will not retard the through traffic, nor the intermediate traffic, but each carriage will run at as high a speed as if it had the whole road to itself. A carriage that loads at the Battery and unloads at Harlem, will run through at full speed; and one that stops at two or three stations below Canal street, to pick up passengers, will run eight miles at full speed, and then stop at two or three stations to set them down and pick up others. And the short traffic, by alternate carriages stopping, will be made somewhat speedier than it can be on rails.

The tractive force of the locomotive is relatively small—30 tons on the drivers to 125 tons total weight; but the steam carriages will have twelve tons on the drivers to 20 tons total weight; its power to start quickly will, therefore, be greater in the proportion of two and a-half to one; and this would enable it to attain a considerably higher average speed on the short traffic. It is understood that on long runs the speed is due to the boiler; but on short runs it is due, in a great measure, to the cylinders, since they get up the speed. Mr. Fisher claims that sixteen miles an hour may be got on the short traffic, and 40 on the through traffic, and intermediate rates on the intermediate traffic, according to the frequency of stops; and these rates will not tax the engines or the way more than they are taxed in English foot passenger practice, or on the Metropolitan railway.

Having thus compared the Barlow tunnel plan with the open cutting plan, worked in two different ways, and shown that the speeds probably will be, for the railway in the cutting, thirteen and three-quarters at the utmost, and for the floor, sixteen to 40, and in the Barlow tunnel it may be 20; we may briefly consider the speed of the rope-traction tunnel plan which Mr. Hawkshaw proposes to go under Holborn and Oxford street. The wire rope is to run all the time at sixteen miles an hour, and the cars are to have means of "slipping the rope," which, we presume, means that they are to catch hold of it in such wise that there will be some kind of yielding, that the car may start gradually. Mr. Harvey, on the Greenwich street elevated railway, has springs on his cars, which are bent by the rope to soften the shock, and to avoid loss of power by friction. But this plan does not work well even at eight miles an hour; and the rope system on the Blackwall railway did not do what is required for the lines now proposed; and we know nothing of Mr. Hawkshaw's new devices, if he has any; and though we don't venture to say what can't be done, we say that the rope system has had a long trial, under the Stephensons, and failed to equal the locomotive; and it must be farther improved before it will equal the plans we have herein set forth at some length, but not fully. But we will suppose, for the comparison, that Mr. Hawkshaw has devised means to take hold of the running rope without wearing it, and to start his car gently, and to do all he requires in this detail. What, then, is to be his speed? It will be liberal to take only one mile from his sixteen for the half speed, while the cars are stopping and starting every half mile. It will require, then, two minutes to run half a mile, and three-quarters of a minute stopping, which is five and one-half minutes per mile, or less than eleven miles per hour average speed. This is about what "Engineering" estimates for a line like the Metropolitan, if its stations were only half a mile apart; and we suspect that Mr. Hawkshaw has aimed merely to equal the speed of that system, and that he has found no encouragement to aim at more.

Which system, then, is wanted? Speed, we presume, is the chief object in the estimation of the customers, who are ultimately to pay for the work. Fresh air is also growing into favor, to such an extent as to mitigate the objection that it would cost considerably to keep the open way free from snow and ice. These two requisites, speed and air, will be most surely found in the cutting. But they must be paid for in land damages, etc. The other plan, that of Barlow, is very comfortable in theory; but in practice we should expect more or less foul air, not to mention want of daylight. And the average speed may be set down at a third less than that on the iron floor. But Mr. Barlow estimates that the running expenses will be small compared with locomotive expenses. Into these estimates we are not prepared to go, and we find no careful estimates in our cotemporary journals.

Having given the gist of all we find worth reporting in the journals and other records, we might stop; but there is a modifying power which often overrules the opinions and even the experience of engineers, and which is very likely to derange such matters in this city. Lobbiers go to the Legislature and buy franchises to sell. These lobbiers know nothing of engineering; they take what has been succesful elsewhere; they exaggerate its success; they get up companies; they bull their stock and water it, and sell it; their job is then completed. And it is good luck if the plan they have established is not a bad one, made worse by being put in a place for which it was not designed. It may have on it the names of engineers; but engineers, like lawyers and other advocates, look out for fees. As one has little faith in a lawyer whom he does not pay himself, so he may about as well look out for engineers whom he does not pay. Not that engineers are less honest than other professional men; but, like others, they are of all sorts; some will resign their employments rather than betray stockholders, or swindle the public; others will hesitate, etc. But any set of lobbiers can get engineers enough to engineer any plan that is already "a success," though there may be better plans, which, whenever set to work, will underwork and render profitless the plans which are thus far successful, only because they have only old and worse plans to compete with. And we suggest to city men, who want these improvements, and intend to take and hold stock in them, that they would do well to employ engineers, on their own account, to get up plans, rather than buy the franchises which lobbiers have got from the Legislature.

In conclusion, we judge from the somewhat vague evidence, that the success of the Metropolitan railway has been greatly exaggerated; that the plan is deemed defective by many, if not most engineers; that it was not planned for the use into which it has unexpectedly fallen; that there are better plans for city traffic; and that it is not at all fit to go under streets where there cannot be openings enough to allow the steam blast, at regular intervals, for at least a third of the way. And, finally, that it cannot be applied in this city so usefully as either of the other plans which we have reported.

In these comparisons we have supposed the highest speeds that can be attained as about equal to what is practiced on the Metropolitan railway. It may be thought that the speeds should be less, so that the expenses and fares may be less. But the time of 55 passengers, for the 4.8 minutes required to go a mile, is worth $2.64, at one cent per minute per person, which is a low average for business men. And this high cost of time ought to be lessened. But those who do not appreciate this economy may assume any lower rate of speed, attended by less wear and tear, and by lower fares. And the saving will be as great in one system as in another, so far as we can now judge; and the comparison which we have made for high speed will hold good for any lower rate that may be acceptable to passengers, and profitable to the carrier.

A Gunpowder Pile-driver was described at a late meeting of the Franklin Institute. It resembles the ordinary pile-driver, except that a charge of powder is exploded, whereby the weight is forced up, where it is caught, till another charge is inserted. A 400-pound hammer can be operated with musket charges, driving the piles quicker and better than the ordinary pile-driver.

IRON ARCHED BRIDGES.

From a paper before the Société des Ingénieurs Civils, by M. Yvon-Villarceau, on the application of his theory of arches to the building of iron bridges.

For several years cast iron has successfully taken the place of wrought iron in iron bridges, with the exception of tubular and suspension bridges. The difference in the cost of wrought and cast iron is not the only reason of this change. In fact, if cast iron offers as much resistance as wrought to compression, it is quite different as regards tension, and it is known that engineers reckon little on the resistance of cast iron when undergoing strains of this nature; they then prefer to use wrought iron, which allows them to obtain much smaller sections than they could if they employed cast iron. The possibility will thus be perceived, in employing wrought iron, of reducing the building expenses of iron bridges where the metal offers resistance to tensile strains. But in supposing it possible to obtain, in this manner, a certain economy, there would be, by that very fact, a reduction in the mass of the construction: a consequence of this reduction of the mass is a diminution in the stability, because it is highly important that the bulk of vehicles and casual weights be as small as possible in relation to that of the construction itself. Finally, the theory of iron bridges, where, at certain points, the metal offers resistance to tension, and at others to compression, is not yet established, and engineers, obliged to have recourse to experience, prudently avoid extending the results to buildings of different dimensions from those they have already tested.

Cast iron bridges do not offer the same drawbacks. They may be so arranged that the metal will only have to resist compression, and the low price of the metal allows a lesser economy of the bulk employed. These motives seem to sufficiently explain the preference given at the present day to the use of cast iron in the building of bridges.

Let us now attempt to show how our theory of arches may be applied to the building of cast iron bridges. An arch of a cast iron bridge comprises three distinct parts. Firstly, the roadway and superstructure; secondly, the cast iron framing comprised between the floor and the extrados, and equivalent to the stone work of stone bridges; and, thirdly, the arch or assemblage of framing, analogous to the voussoirs of stone bridges, and which will fill the place of these latter. It will be first remarked that the framing of the system equivalent to the stone work is in the shape of hollow prisms with a vertical axis, ended at the upper part by an horizontal plane, and at the lower part by a curved surface in contact with the extrados of the arch. This arrangement of prisms agrees the more exactly with what we considered in our paper on the building of arches of bridges when their parts parallel to the road are more limited. The objections raised by some persons against the theory of normal action at the extrados in stone bridges could not be applied in this case, so that that theory may be said to apply more exactly to cast iron than to stone bridges.

The transition of the theory of stone bridges to cast iron bridges may be made in the following manner. Let us consider one of the vertical prisms forming the bulk of the bridge, and let us compare its weight with the weight of this prism. When considered as solid, we will deduce therefore the weight of the unity of volume, or the density of this prism. The first condition to be fulfilled is the coincidence of the actual center of gravity of the prism, and of that of the prism when solid ; the second is that all the prisms have the same density in the whole of the construction.

These two conditions are easily filled ; it would suffice to obtain the figure of the resulting internal space. Let us pass on to the framing constituting the voussoirs ; their density would be obtained in the same manner as for the other prisms, and we will obtain at once the same conditions as regards the equality of density and the position of the center of gravity. If the theoretical conditions are to be rigorously carried out, there would remain to reduce on the intrados, the surface of contact of the voussoirs on the small space which separates the actual and imaginary intrados.*

There remains to be examined the question of pressure. In the whole extent of the structure, considered as filled, the pressures are equal to those produced by a liquid, the density of which would be equal to that of the structure, and the upper surface of which would be loaded with a weight equal to that of the roadway and superstructure ; consequently, the pressures transmitted by the structure on the vertical sides which form its boundaries act horizontally, and the pressures received by the extrados are normal at its surface. To pass from these pressures, estimated on the hypothesis of continuous surfaces, such as those of the prisms or stone voussoirs, to those which answer to the case of prisms or hollow cast iron voussoirs, it evidently suffices to multiply the first by the relation of the surfaces which are in contact with the filled (solid) system with the corresponding surfaces of the hollow system.

It is evident that in the cast iron prisms or voussoirs the only surfaces of contact to be taken into consideration, are those capable of effectually transmitting pressures. (For instance, no notice ought to be taken of the surfaces of the cross bars used solely for forming connections in the direction of the axis of the arch.) The pressures thus obtained ought not to exceed a previously determined limit. Let us add that it would be always possible to render the pressures constant on each unit of surface—the whole extent of the arch, because, within large limits, the surfaces of contact are to be disposed of.

In stone bridges subjected to the conditions of stability we have laid down, if we have given us the opening of the arches, and the ordinates of the summit of the intrados, and of the springing lines in relation

* The theoretical conditions might be realized without touching the joints, by giving to the arch a constant thickness, e, which would render the extrados and intrados perfectly parallel to each other. For this purpose let $\tilde{\omega}$ be the weight of the unity of volume of the voussoirs, as previously defined, and $\tilde{\omega}'$ a variable density, according to the formula

$$\tilde{\omega}' = \tilde{\omega}\left(1 + \frac{1}{6}\frac{e}{\rho}\right),$$

in which ρ represents the radius of the curve ; the space of the voussoirs would be got rid of to realize the density $\tilde{\omega}'$ relatively to each by fixing the center of gravity at the point determined by theory, and the pressures could nevertheless be calculated in retaining in the general formulæ the quantity $\tilde{\omega}$.

In this case the actual intrados would be confounded with the imaginary one, of which it would suffice to consider the co-ordinates.

Preference, it appears, ought, however, not to be given to this solution ; it is better, in fact, not to extend the contact of bodies undergoing considerable pressures to the extreme limits of the flat surfaces of contact. On the other hand, we are accustomed to see the thickness of arches increase towards the springing line, and the effect upon the eye is generally pleasing.

to the horizontal plane which forms the limit of the surcharge, it will be found that the section of the intrados is nearly determined, independently of the thickness of the keystone, and the result is all the more exact when the densities of the materials of the surcharge and of the arch are the nearer equal. The whole bulk of the structure being then sensibly constant, the stability increases more rapidly than in proportion to the thickness of the arch, because it would be in proportion to this thickness if the mean pressure per unity of surface were constant, and this mean pressure decreases in inverse ratio to the thickness of the arch. As regards stability, it would therefore be better to increase the thickness of the keystone until there would be above it but the strictly necessary thickness of overcharge. This is not always done, and the reason is evident, because the price of a cubic meter of stone, cut and dressed as voussoirs, exceeds to an enormous extent that of filling up materials. In cast iron bridges, where a similar disproportion does not exist, there is nothing to prevent the arch from having the complete thickness demanded by a design. In the previous reasoning it is supposed that the casual overcharges result usually in increasing the pressures in the joints, so that it is to the interest of the engineer to diminish those which show themselves in the absence of any overcharge. When we consider the chances of decrease in the pressures, such as those which would result from slight motion of the soil, or sinking of the piles, one is lead to avoid reducing too low the pressures corresponding to the normal state of the arch. But if it be remarked that the casual surcharges are for cast iron bridges in a greater relation with the bulk of the structure than for stone bridges, this circumstance would be a motive for reducing the normal charges of cast iron bridges. Besides the connections made between the framework by bolts, present, to ward off cases when the casual pressures would fall a few points below zero, advantages incommensurably superior to those that could be expected from the cohesion of the mortar in stone work.

Let us finally add that if, without increase of expenses, it can be so arranged that the densities of the structure and voussoirs, understood as we have before said, be equal, the calculations to be done will be sensibly abridged, either directly or by means of special tables.

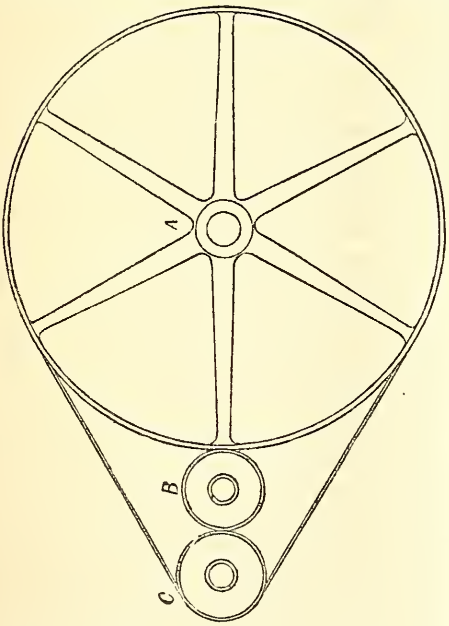
A New Steel-Headed Rail. — The "Engineer," after pointing out the various defects of welding steel slabs upon rail piles, expresses great confidence in the new (?) process of Mr. E. Gray, of Sheffield, which it describes and illustrates at length. The process is simply *casting* a steel slab upon an iron pile. The iron pile is heated and set in an ingot mould, but it does not fill the ingot mould; a space, say one to two inches wide, is left at one side, into which liquid steel is poured. The steel is expected to unite perfectly with the iron. The whole is then rolled into a rail, the steel surface forming the head.

We do not think this process, as described, can be relied upon, but that some radically new means and apparatus must be developed for overcoming the many practical difficulties. Our reason for thinking so is, that we have tried this plan without constant success—indeed with very uncertain and variable results. We have heated and set up in ingot moulds, iron slabs and blooms for rails, and iron cores for axles. Liquid steel poured into the mould would fuse and soundly weld to such parts of the iron as were *clean* and very hot. The practical difficulty is in getting out of a furnace, and setting up and centering in a mould, a heavy mass of iron, with such celerity that the surface shall not become much cooled and oxydised. Another more serious difficulty occurs in the case of casting a mere surface of steel upon an iron pile or bloom. If the iron bloom is made to perfectly fit the mould on the three sides not to be covered with steel, it cannot be got into the mould hot—the operation takes too long. If the iron bloom does not perfectly fit the mould, the steel will run all around it in thin fins, which have not mass enough to hold their heat and weld uniformly. The three sides of the resulting ingot, intended to have iron surfaces, have, in fact, facings of steel, partly welded and partly chilled upon the iron. When such an ingot is rolled it is sure to crack in the flanges, and to make a rough, bad rail.

We have also made several hundred rails by setting up heated iron or steel rail ends in the center of a mould, and casting steel around them. The mass of liquid steel being so thick, and the mass of the core being so small, a good weld generally resulted, but *not always*, and this uncertainty led to the abandonment of the process.

The theory of welding steel to iron is excellent, and the practice is very satisfactory when the conditions are properly provided for. We have seen absolutely perfect welds made in this way—welds in which no test could discover the slightest want of continuity of the mass. But the present practical difficulties must be overcome. The plan shown in the "Engineer" is not trustworthy; nor is it new. Dr. Percy describes the same thing as proposed for the manufacture of tyres. And we have heard that it was proposed in this country at a much earlier date than our use of it. Here is a fine field for experiment, and we hope that this grand principle will be successfully worked out.

PULLEYS FOR SHORT BELTS.—Messrs. Gwynne, centrifugal pump makers, of London, use the arrangement shown in the cut, for saving space and strain in the use



of short belts. The driven pulley C is placed close to the driver A, so that the belt touches but a small portion of its circumference. The belt, therefore, has to be very tight; and to relieve the journals from the great pressure and wear thus imposed, the pulley B is placed intermediate between the others. This intermediate pulley is recessed in the center of its face, so as to bear on the others at the edges only. The arrangement is said to work well, and is more fully illustrated in "Engineering" of January 22.

LARGE HYDRAULIC TESTING MACHINE. —Messrs. Paulding, Kemble & Co., West Point Foundry, are making for L. B. Boomer, Esq., the eminent bridge builder, a machine for testing full-sized parts of bridges—rods, castings, etc.—up to 40 feet length and 400 tons pressure, either thrust or pull. The cylinder is 17½ in. diameter, and nine inches thick; the stroke eight in. The ram is single acting, being brought back by a rack and pinion. The cylinder is hung on trunnions—in fact it would be taken by an artilleryman for a 17½ in. mortar. When pointed in the direction of the 40 ft. bed-plate, it pushes directly upon or compresses the piece to be tested. To bring a tensile pull on the piece, the cylinder is turned away from it, and the power is brought to bear on it by means of a cross head, cross tail, or head block, and two side rods. The side rods are forged from Bessemer steel, and are four inches square. The cost of the machine will be about $5,000. Such a machine, for testing full-sized parts, has long been wanted in this country. The tests of little, short specimens, turned down to a mere wire in the middle, are not accurate, and the changes of figure are not easily measured.

STEAM CULTIVATION.—The success of steam cultivation was long ago established, and to say that steam is cheaper and better than horses in the field is as trite as to say the same of it on the railway. It is no longer a question of steam *v.* horses, but of the newest *v.* the earlier forms of steam tackle. More powerful engines, of much better construction, and worked at higher speeds are now in use, and some of them, working up to 100 indicated horse power, are hauling six and even eight-furrow ploughs in moderately stiff land, or dragging cultivators from 12 ft. to 15 ft. wide, and that at a rate of four miles an hour. The money saving had been proved by many cost sheets, and as for the work itself, it could be done in all weathers, done upon land which horses could not touch, or where they could not stand, done at a faster pace, the pulverization of the soil being as the square of the speed at which it is knocked to pieces; and then there was not a single one of the hoof-tracks, where horses' feet, like pavior's mauls, ram the ploughed earth into a hard pan like a pavement—hoof tracks, of which, with a full team in heavy ploughing, there may be as many as 300,000 to the acre.

THE SUEZ CANAL.

AUTHENTIC ACCOUNT OF THE WORKS, MAINTENANCE, DIFFICULTIES, WORKING, ETC.

Compiled from a letter by Mr. John Fowler to the London "Times."

Port Saïd Harbor.—A harbor for the entrance to the canal has been constructed at Port Saïd by running out into the sea two breakwaters formed by artificial blocks of stone. These are composed of one part of hydraulic lime from France, and two parts of sand obtained on the spot, and are therefore really hard mortar. The harbor is intended to answer the double object of protecting vessels from heavy seas and of arresting the alluvium brought down by the river Nile, so as to prevent its choking up the channel. The western breakwater extends from the shore 2,400 yards in a straight line towards the north, and then with a slight angle towards the east extends 330 yards further. The eastern breakwater leaves the shore at the distance of 1,530 yards of the commencement of the western breakwater, and extends nearly north for a distance of 2,070 yards, at which point it is 760 yards from the western breakwater, and this distance constitutes the width of the entrance. The portion of the harbor affording shelter to vessels is nearly 500 acres in extent, and, although the depth of water is not sufficient for the largest men-of-war, it is quite sufficient for ordinary merchantmen, if the present depth be maintained.

Large quantities of alluvium are constantly brought along the shore from the Nile, and since the construction of the western breakwater this deposit has changed the line of the shore, while large quantities have found their way through the interstices of the artificial blocks of which the breakwater is composed, into the harbor, and are forming deposits there; it will be found necessary to make this breakwater solid. It is possible this outside accretion may require at some future time a prolongation of the breakwater, and it may be that northerly winds will occasionally bring sand into the harbor; but I do not consider such contingencies to constitute any real objection to the design, or likely to be formidable in expenditure, considering the gigantic character and objects of the whole undertaking.

Divisions and Sections of the Canal.—The canal may be conveniently divided into the following portions:

	Miles.
1. Port Saïd through Lakes Menzelah and Balla to near El Ferdam	37
2. From near El Ferdam through the great excavation of Seuil d'el Guise to Lake Timsah	9½
3. Through Lake Timsah	5½
4. From Lake Timsah through the excavation of Seuil du Sérapéum to the Bitter Lakes	7½
5. Through the Bitter Lakes	23½
6. Through the deep portion of Chalouf Cutting	5
7. Thence to Suez and the end of the canal.	11
Total	99

With minute exceptions the whole of the canal is now being excavated and completed according to one or other of the following sections:

1st. 196 ft. in width at the surface of the water, and 26 ft. deep for 72 ft. at the bottom. The slopes are two horizontal to one vertical, with one or more horizontal benches of 10 ft. in width, according to the depth of the cutting.

2d. 327 ft. in width at the surface of the water, and a similar depth of 26 ft. for a similar width of 72 ft. at the bottom. The lower part of the excavation is also two horizontal to one vertical, but the slopes above and below the surface of the water are five to one, and a horizontal bench of 58 ft. connects the two slopes.

It will be observed in the description of the second section that the slope at the surface of the water is flat (five to one), and provision is now being made for protecting this slope with rough stone pitching, trimming the upper slopes, and otherwise treating it as a finished work. This may be safely done, because the section is so arranged that the canal may be widened at any subsequent period without disturbing any of the work already done. With the first section, however, the case is different. This section has been adopted in the deep cuttings to effect the largest saving possible in the quantity of excavation, and, therefore, if a future widening of the canal is required, one or both side slopes must be thrown back, and a considerable portion of the present work interfered with. As a rule, no stone pitching or other protection against the wash of passing vessels, or wind, or current, has been provided for the part of the canal where this section has been adopted, although the slope at the surface of the water is two to one.

At each end of the Bitter Lakes careful provision is now being made by temporary weirs and sluices at the sides of the canal for the admission of water into the lakes from the Mediterranean and Red Seas. This provision has been calculated with reference to the time and quantity of water, and a sufficient margin appears to have been given for possible contingencies.

THE WORKS AT SUEZ.—These consist chiefly of an entrance channel into the Red Sea, increasing gradually from 72 ft. in width at the bottom to 980 ft. of a basin or dock, and a considerable extent of reclaimed land.

WORK DONE AND TO BE DONE.—The total quantity of work in cubic meters of excavation originally required for constructing the canal according to its present dimensions and design was as follows:

	Cubic meters.
Total work	78,000,000
Work executed up to Dec. 15, 1868	53,000,000
Leaving still to be executed	25,000,000

The number of men, animals and materials which were on the ground and available for the work on the 15th of December, 1868, was as follows:

Workmen	8,213
Camels	368
Donkeys	116
Dredging machines	60
Inclined planes of railways	22

The quantity of work yet remaining is very large, but taking the progress made during the last few months, and applying the same rate for the future, it appears to be possible that in the absence of some unforeseen contingency the canal may be sufficiently completed for the purposes of traffic during the present year.

MAINTENANCE OF THE CANAL.—The question of maintaining the canal and its harbor of Port Saïd permanently open for traffic has excited almost as much professional and public attention as the construction itself, and in some minds probably much greater doubt and difficulty have been felt on this than on any other point.

The difficulties of maintenance may be divided as follows:

1. *The Prevention of Nile deposit from choking up Port Saïd.*

The remedy for the mischief, which may be said to have commenced and to be now continuing (and to which we have referred above), is either to admit the sand to pass through the breakwater and then depend upon dredging, or to make the breakwater solid, and encounter the difficulty, whatever it may be, of its greater accumulation outside. The rate of accumulation in the angle formed by the western breakwater was naturally very rapid in the commencement, because the area was small, and the water was impounded in such a position as to be almost without motion; but as the new shore formed by the deposit advances seaward this rate of advance is rapidly and constantly decreasing. The time has not been sufficient to collect adequate observations by which any law or formula could be founded to represent the future rate of the advance, but it is, however, very clear that many years must elapse before the line of shore can possibly reach down to the angle of the breakwater, and it may be that at or near this point the accretion seaward will cease altogether; but the greater probability is that, although it may have become small, it is still going on, and the necessity of extending the western breakwater, at some future time, further into the sea, is likely to be required. No apprehension need be entertained as to the channel and harbor being silted up and destroyed, but at the same time considerable expense in dredging will be constantly required.

2. *The Impossibility of Preventing the Sand of the Desert Blowing into the Canal in Quantities totally Unmanageable.*

This objection has been felt to be one of great weight, and when it was considered generally and without the correction of local knowledge it appeared to be fatal, because if the whole or nearly the whole distance from sea to sea had been through a desert composed of fine drifting sand it would have been hopeless to maintain the canal open; but, fortunately, the only portions of the canal which will be liable to be affected by the sand of the desert to any extent worthy of consideration are the two excavations on each side of Lake Timsah—viz: Seuil de Guise on the north, and Seuil du Sérapéum on the south. Fortunately, a tolerably satisfactory means of ascertaining the annual amount of drifting sand has been afforded by an investigation lately made during a period of twelve months, and the result is that 40,000 cubic yards was found to have passed into Seuil de Guise, and 270,000 cubic yards into Seuil du Sérapéum. These quantities, no doubt, are very large, and it is quite possible that during some years they might be exceeded, but the company are making provision to diminish the quantity by trying experiments with trees and shrubs, so as to plant the slopes and the ground for some distance on each side of the canal. It is also probable that water from the fresh-water canal will be made available for forming an extended oasis at and around this portion of the canal. These operations will be somewhat expensive, although they are doubtless prudent and desirable, but after every precaution has been taken it will be necessary to keep one or two powerful dredges in Lake Timsah to keep the canal clear from drifting sand.

3. *The Difficulty of Protecting the Banks against the Destructive action of the Wave caused by passing Vessels.*

It will be found necessary to make a proper and immediate protection of the slopes by stone pitching above and below the surface of the water along the whole course of the canal if the traffic is to be conducted at a reasonable rate of speed; the engineers of the Canal Company have arrived at the same opinion. This work will no doubt be executed much more conveniently and economically after the canal is opened throughout, and the large quantity of stone required can be conveyed without charge; but, on the other hand, it will be more difficult to place the stones below the level of the water, and probably the slopes may have sustained some mischief before the work can be done.

4. *The Impossibility or Difficulty of Supplying the Abstraction of the waters of the Bitter Lakes during the Evaporation of the Summer Months through the Ordinary Section of the Canal between the Bitter Lakes and Suez.*

The vast extent of the Bitter Lakes (100,000 acres in superficial area) when connected with the tidal Red Sea by the Chalouf excavation, will produce in the summer months, when the evaporation is greatest, peculiar currents and hydraulic phenomena. The largest daily evaporation or abstraction will amount to about 250,000,000 cubic feet of water, and this will be chiefly supplied from the Red Sea, which is far nearer than the Mediterranean, and has a tidal range of about 6 ft. in spring tides, and 2 ft. at neap tides, while the Mediterranean has a far less tidal range. The currents which will thus be created by evaporation and tide will be sufficient to assist or retard navigation, as they will probably approach, if not exceed, two miles per hour, but they will scarcely be strong enough to affect injuriously the bottom or sides of the channel through the Chalouf cutting after the proper protection by stone pitching has been carried out.

It is possible that a strong south wind may somewhat increase the velocity of this current by slightly raising the ordinary tide at Suez, and that lateral absorption, evaporation, and waste round the shores of the Bitter Lakes into, and through, the sand of the desert may increase the amount of the water to be daily supplied; but these disturbing causes will not probably be sufficient to make any appreciable difference in the velocity. It would, however, have been desirable, in my opinion, that the canal should have been originally constructed on enlarged dimensions between the Bitter Lakes and the Red Sea, if the resources of the company had permitted.

Traction Power to be Employed on the Canal.—A special committee, or commission, has been engaged for some time in investigating this question, and has considered many expedients and suggestions. At one time it thought that a continuous chain along the bottom of the canal, similar to that used for the ferry at Portsmouth, would be applicable, but it is now understood that steam vessels (except those with paddle-wheels) may use their own power, and that any vessel may be towed through the canal by steam tugs, the speed to be limited in all cases, as may be settled hereafter. This is doubtless the best decision, both for economy and convenience.

Several important questions suggest themselves in the working of the canal, such as the impossibility of two large vessels passing each other until the canal is enlarged; but this difficulty must be dealt with by regulations very similar to those adopted on a single line of railway. If, however, the traffic should rapidly become very large, it is possible that several passing places will have to be provided without waiting for the widening of the whole canal.

A strong side wind would also be a considerable difficulty, and occasionally it may be found to be almost impossible to keep a large vessel from the sides of the canal. In the Caledonian canal it is well known that this difficulty is frequently experienced even with small vessels, but in Egypt very strong winds from the east and west are not common, and the difficulty will probably not amount to more than a simple retardation of the speed of the vessel, and the necessity of lowering all masts and rigging capable of being lowered, but one or two attendant tug vessels, when required, can be made available for the purpose of enabling a vessel to keep the channel of the canal. Doubtless many unexpected matters, both of difficulty and convenience, will develop themselves in the working of the traffic, but these will be best dealt with as they arise.

PROBABILITY OF THE USE OF THE CANAL.—The Suez Canal is so peculiar in itself and in the manner in which localities are affected by it, with respect to their maritime distances from each other, that it is almost impossible to foresee the manner and degree in which it will attract traffic to itself. It may, however, be assumed with tolerable safety that, provided the canal be maintained in full depth and efficiency, and the charges made for its use are not unreasonable, the steam passenger and mail traffic now carried on between Europe and India will chiefly pass through the canal. It may with equal safety be assumed that sailing vessels, which would not only require steam tugs through the canal, but also down the Red Sea, will not use the canal. A certain amount of local traffic between the Mediterranean and Red Sea ports will no doubt use the canal.

The great element of uncertainty, and one on which the commercial success of the Suez Canal will chiefly depend, is whether new sailing vessels, with adequate auxiliary steam power, specially adapted to the canal and the Red Sea, will be constructed, so as to divert the large traffic now being carried around the Cape. I think enterprising firms will try this experiment, and if successful, the Suez Canal will secure a great position both for usefulness and profit.

ENGINEERING IN SPAIN.

FOREIGN CAPITAL AND TALENT—BAD RAILWAY MANAGEMENT.

From "The Engineer."

No country owes so much to foreign labor, foreign science, and foreign capital as Spain. Indeed, it is wonderful that English, French, Belgians, and Hebrews, should have done as they have done for a country where the peculiar nature of the soil and the eccentric character of the inhabitants must have presented difficulties at every step. The credit of having introduced the railway system into Spain is divided between an English engineer, Mr. Vignoles, a Jewish banker, Mr. T. Péreire, and the late M. Perdonnet. The latter, by the way, made a serious mistake, when he said, "Railways will change the aspect of that country." They have no more altered the customs of the Spaniards than the recent revolution has altered the state of the "*Caminos de Hierro.*" As to the construction of railways, and their subsequent repairs and management, the Spaniards have had very little to do with them. The lines were surveyed by foreigners for a good reason, namely, that very few Spaniards are sufficiently acquainted with the exact sciences to make a correct plan or to level a trial line.* The rails, turntables, switches, &c., were supplied by English or Belgian ironworks. The rolling stock was supplied partly by English, partly by Belgian and French builders. Several Belgian firms are said to have supplied rolling and permanent stock to Spanish railway companies on condition of taking part payment in shares or bonds, a transaction which has proved ruinous to them, notwithstanding the government guarantee.

The working of railways has been left as much as possible, for obvious reasons, in the hands of the native functionaries. Gentlemen of this class are as numerous and as zealous in Spain as they are now in France, or as they were twenty years ago in Austria. Railways under official management are easily recognized. Mail trains arriving at Madrid five or six hours behind time ;† express trains carrying cattle and metals, as we have ourselves seen on the "Norte"; passengers turned out of their trains at night, and obliged to wait two or three hours in the open air, without refreshment or shelter; trains starting before the advertised time of departure. Such is Spanish management. And these irregularities are so frequent that they have become regular, punctuality being the exception. Native passengers do not complain as often as might be expected, because they are, as yet, not sufficiently acquainted with railways to know what they should be, and what services they might render under proper management. Wherever a large foreign staff is employed—as on the Ciudad-Real and Badajoz line—punctuality and even comfort may be expected.—The labor supplied to Spanish railway com-

* This is certainly not true of the same race in Cuba. The study of engineering is very largely and thoroughly pursued by Cubans, in our scientific schools, especially in the oldest if not the best of our engineering schools—the Rensselaer Polytechnic Institute.—*Ed. V. N.'s Mag.*

† This frequently occurs on the southern lines.

panies is divided between English platelayers, French fitters, Piedmontese underground excavators, Belgian openwork excavators, and Spaniards, who excel in no particular trade.

Spain possesses a very rugged and barren soil, but the mines of the Peninsula are very rich; and some of the richest are, by a sort of natural compensation, in the most barren districts. Coal, iron, copper, and lead ores are very abundant. Santander exports large quantities of "red ore" to the Welsh iron districts. The colliery (Cuenca) of Belmez, situate in the Sierra Morena, between Castuera and Cordova, appears likely to prove very rich. We believe that all the coal consumed by the "traction" of the Ciudad-Real and Badajoz line is supplied from this mine, though it has not been worked long. The Cuenca of Belmez was surveyed by French engineers some years ago. It is now conceded, together with the Badajoz line, to a French company (Fines-Lille.) The oldest mine in Spain in probably that of Almaden (mercury); that is worked, we believe, by Spaniards. Almost all the others are surveyed and managed by foreign companies, foreign engineers, and foreign work men. The mines of Thelva, Tarsis, Rio Tinto (copper), and Alcañees (tin), were surveyed and claimed by a French engineer—M. Ernest Deligny—and put into working order by a French capitalist—the Duc de Caze. Huelva is now in the hands of an English company.

The harbors of Spain have not given much employment to foreigners. The big moles of Tarragona, Barcelona, and Cadiz, were made entirely, we believe, without foreign assistance, and paid for by the State. But the canals have required foreign engineering talent and foreign capital. Thus Spain is indebted to foreign nations for her mines, railways and canals. She is also deeply indebted to them for money, the Spanish government having frequently issued loans, which have been subscribed in a great measure by English capitalists. Three countries especially—England, France and Belgium—have assisted Spain in such a manner as to give substantial proofs of their goodwill towards the Spanish nation, and of their confidence in the traditional honor of the Spaniards. Unfortunately the late government have destroyed that confidence and repudiated their engagements with such coolness as to induce a suspicion that they never intended to fulfil them. We may reasonably hope that the present government has better intentions and a more honorable character; but it will be a hard task for the provisional or any other administration to restore the national credit.

Converting Cocoa-nut Husks into Fibre.—The "Mechanics' Magazine" thus describes the process: The shell or outer covering of the nut is first soaked in a tank of water kept warm by steam. When sufficiently soaked, the shells are conveyed to a hopper, through which they are fed to a crushing mill, which consists of two coarsely-fluted rollers, between which the shells pass and are crushed. They are removed thence to the fibre mills. Here the shells are drawn in between two rollers, behind which are arrangements for tearing away the finer fibre and leaving the coarser in the hands of the operator, who presents first one and then the other half of the shell to the action of the mill. The coarse fibre is then carried away and prepared for conversion into brushes and brooms. The finer portions of the fibre are removed from the mill, and undergo a process of final dressing. This is effected by feeding them through a hopper into a circular screen, in which an Archimedean screw rapidly revolves. The fine fibre is delivered at the mouth of the screen, whilst the dust and smaller particles of fibre are carried through the sieve. The fibre thus produced is used for making mats and matting; the siftings find a ready sale with florists and market gardeners for manure. The sweepings and refuse are collected and burned under the boilers.

Engineers and Architects.—The kind of tacit estrangement which now exists between architecture and engineering, imperils public interests, and results in the abuse of popular taste. The engineer can no more afford to work without the architect on his great works than the architect in similar case can dispense with the engineer. In the one case we are threatened with mere size and solidity, without sightliness; and in the other, with works which promise an antiquarian rather than a true artistic interest as productions of our own day; while the art of the architect threatens to fail in its highest aim—the elevation of public taste and the excitement of popular sympathy—because it refuses to bend to the wants and discoveries of the time.

It is in no sense derogatory to the prestige and honor of either profession that the public should long to see the divorce between them annulled. Each has its special excellence and its special province; we only desire to insist that the intellect of both is essential to great and lasting successes in our public structures of every class. Life is far too short in our day, the competitive principle too active, and the exigeant demand for speedy execution of our work too pressing, to allow of any one man achieving high excellence in the character of architect and engineer at once, as we now understand the high functions of the two professions. Your modern engineer can as little be expected to design a town hall or a cathedral up to any noble mark, as your architect can be asked to construct a suspension bridge or a railway station on a grand scale. There may be, and have been, here and there, eminent instances of men gifted with the rare combination of engineering and architectural talent; but they are so scarce and so far between as not to affect our argument. How many architects, for example, are there among us to-day, who could, *de novo*, and without existing models, at once design *and* construct a Westminster Abbey or a St. Paul's Cathedral? Similarly, it may be asked, where is the engineer who could construct *and* design them? The architect may be able to design, and the engineer to construct works of such a mark, but it is idle ever again to expect that either can do both unaided by the other.—*The Architect.*

PERMANENT WAY OF THE PENNSYLVANIA RAILROAD.—It is highly gratifying on many grounds—comfort, security and engineering fitness—to strike the new permanent way of the Pennsylvania railroad, after rattling over the tracks of various roads farther east. The smoothness, the apparent absence of joints, the sailing motion, in comparison with the hard gallop of wheels over unfastened rail ends, is even better than English railway riding, because of the lateral and vertical articulation of American cars. The steel rails of this line, now in use and coming into use as fast as the Pennsylvania Steel Works can turn them out, are four and one-half inches high, four inches wide on the flange, and weigh 67 lbs. per yard. This height gives room for a thoroughly good fish-joint. The sleepers are two and one-half feet apart centers, laid on good ballast—generally blast-furnace cinder.

RIVER FLOODS.

LACK OF PREVENTION—DESTRUCTIVE EFFECTS ON PROPERTY, HEALTH, SEWAGE AND DRAINAGE.

In this country, perhaps less than in England, annual sufferers by flood take marvelously little pains to keep their property and dwellings out of reach of inundations, and still less to change the beds of streams and the defences of banks to avoid their destructive effects. The following considerations on the subject are from "The Engineer:" Once a year at least, and frequently oftener, inundated lands and submerged fields testify to the total absence of restraint imposed upon our rivers and streams, and the fury with which they exercise their uncontrolled depredations. Bearing in mind the patient passiveness and apathy that mark the conduct of the owners and occupiers under these annual inflictions, one might almost be inclined to believe that, instead of ruin and devastation constituting their invariable attendants, they were accompanied with the same advantages that follow the periodical inundations of the fertilizing Nile. Not only are the overflowing waters permitted to extend their ravages over outlaying districts and the open country, but there are very few towns where any provision is made to check the progress of floods and arrest the violence of the torrent. It is only the other day that Manchester finally decided, when driven to extremities, that something must be done in the matter, and has undertaken the construction of the necessary works, under the advice and superintendence of one of our most eminent hydraulic engineers.—If—in the case of towns—precautionary measures are adopted only after so much hesitation, procrastination and uncertainty, it is difficult to predict the period at which, the evils resulting from floods in the open country will undergo any permanent abatement. The embankment of a river for that portion of its course running through a town improves the river itself, and a handsome wall adds to the appearance of a city. But beyond this no good is effected. Above and below the wall-bound stream the waters remain in their state of original liberty, ever ready, upon the first addition they may receive to their turbid contents, to break out into open rebellion. It is even questionable whether the penning up, as is were, of the contents of the swollen channel, does not increase the violence of those portions of the stream unconfined by the granite boundaries. That the improvement—whether it consists of widening, narrowing, strengthening, or deepening the river—is confined altogether to the small portion affected, there can be no doubt. It is apparently incredible that we, who, in the nineteenth century, have rendered all the powers of nature obedient to our will and subservient to our interests —we who have made the opposite elements of fire and water administer to our comforts and contribute to our welfare—should permit our rivers and streams to range at large unchecked and unrestrained, and annually to commit ravages costing thousands to repair.

It is not our province to inquire into the reasons why houses come to exist in such close contiguity to rivers notorious for inundations, or why people elect to reside in abodes, which are reared upon so fearful a source of sickness and death as damp foundations. It has been lately advocated by a well-known authority, that every dwelling house should stand upon its own area of concrete or other waterproof substratum. The mere insertion of a course of slates, a layer of asphalt, or a coat of cement above the footing course, is not sufficient to endow a house with immunity from those evils which directly result from too close a communication with a damp soil. Unquestionably the true principle is that which would require the whole of the area, upon which the building is raised, to be overlaid with a waterproof layer; and we trust that we shall ultimately witness the enforcement of this proviso, by the authorities charged with the supervision of the erection of new buildings.

There is another light in which to view the evil results springing from the wholesale inundation of arable and fertile land, which materially affects the great question of sewage irrigation. It is often urged that it would be impossible to apply sewage to lands that are particularly well situated with regard to levels, and in other respects admirably adapted for its reception, owing to the great quantity of water existing in and about them. The agriculturist exclaims, "We have more water than we know what to do with, and you want to send us a still larger supply!" This brings us to a consideration of another feature in connection with the utilization of sewage, which is not regarded with the attention it deserves. It is the question of drainage. Lands subject to periodical floodings must necessarily present greater obstacles to the carrying out an efficient system of drainage, than others more favorably located. One of the first steps taken at Barking was thoroughly to drain the subsoil; and, in fact, this operation was carried out to a greater extent than was absolutely required, as experience subsequently demonstrated. In an instance of the nature alluded to, it will, nevertheless, be admitted that it was better to err upon the safe side. A work of supererogation was infinitely preferable to the fault of omission. If a farmer will not go to the expense of draining his land and putting it in proper order to benefit by the application of sewage, he cannot in common fairness, allege that the non-utilization of that fertilizing medium is due to a self-inherent defect. Moreover, supposing that all the lands subject to inundation were properly drained, yet the overflowing of the natural water-courses would, for a time at least, effectually prevent the application of sewage. From the statements already made, it is manifest that by the annual outbreaks of our rivers and streams, many thousands of acres are either permanently or temporarily prohibited from benefiting by the application of sewage. What constitutes a further aggravation of the evil is that these very lands—from their physical features and natural position—are calculated to receive the sewage by the readiest and cheapest method possible, namely, that of gravitation. We could point out instances where land situated along the banks of the Medway, and, in every sense well adapted for the utilization of sewage, cannot be so employed in consequence of the floods to which it is constantly subjected

It would scarcely be reasonable to urge that all rivers should be prevented from trespassing beyond the limits of their natural channels, by the erection of heavy walls similar to those constituting part of the Thames embankment. At the same time, there is not the slightest doubt but that in numerous instances, especially in those localities where labor and materials could be procured comparatively cheaply, it would pay, in the long run, to construct a sound strong wall, instead of the stereotyped bank with its central core of puddle and inner and outer slopes. Only those who have had the care of these banks are acquainted with the watching they require, amounting at times to a regular patrolling. They are a continual source of anxiety and annoyance to the proprietors of the lands protected by their ambiguous influence, and a never-ending cause of expenditure.

There is no question but that the tortuous course of some rivers, the multiplicity of twists and abrupt bends, mainly contribute to the occurrence of floods. It is in the "elbows" that the marshes and swamps principally exist. If we imagine a rapid torrent coming down a straight reach, and on a sudden encountering an abrupt bend, nearly at right angles with its previous course, the volume of water cannot adapt itself to the sharp sinuosity, but overleaps the bank, floods the land situated in the concave part of the "elbow," and whatever is left of it falls into the channel beyond the bend.—Were more attention paid to improving the course of our rivers and the cross section of their channels, the work of the banks would be considerably lightened. As it is, they have not merely their legitimate duty to perform as confining or retaining walls, but in the majority of instances they have to withstand a pressure and violence which ought never to be brought upon them, which is due to the crooked character of the river's course. Floods are due, not so much to the gradual rising and swelling of the waters so as to uniformly overflow the banks, as to the fact that they accumulate with a rapidity exceeding that with which they are able to get away. Owing to the impediments in their course they become piled up, as it were, at certain points, to a height far exceeding that of their confining banks, while at others their level is scarcely perceptibly altered. If a little more money were spent in widening, straightening, and deepening the defective portions of our rivers and streams, we should hear less of banks being breached, meadows flooded, and towns inundated.

COAST DEFENCES.

From a lecture by Col. Jervois, before the Royal Institution.

Coast defences in Anglo-Saxon times consisted, in the main, of predatory incursions and plundering expeditions. The progress of civilization has introduced better usages into the practice of modern war; but if it had not, the length of our coasts is far too great, and the accessible points far too numerous, to render it possible to fortify them all. When we speak, therefore, in the present day, of our coast defences, we must not be understood to advocate a vain attempt to secure by defensive works every vulnerable point, but to provide for the protection of our national dockyards and arsenals, and of our main commercial ports.

For the general defence of a vast empire we must first of all, and mainly, depend upon our fleet. It is to the fleet we must look for our first line of defence against invasion, to maintain our communications with our foreign possessions, and to protect our commerce at home and abroad. But the bases on which our naval power must rest are the ports, dockyards, and arsenals, in which our fleets and squadrons are harbored, coaled, and refitted. Thus we have naval establishments at Portsmouth, Plymouth, Chatham and Pembroke, at home; at Bermuda, Malta, Gibraltar, and other places abroad.

These places are the roots from which our naval power springs, and they require special protection against attacks that may be made upon them during the absence of the fleet, either by hostile naval forces alone, or by combined naval and military expeditions. Even if it were possible that a fleet sufficient to fulfill all these duties could be maintained, such an application of the resources of the nation would lead to an expenditure of public money, far exceeding that which would suffice for the defence of the country with the aid of other means. Further, if the several sections of our navy were employed for the protection of the arsenals whence they are maintained, we should be using the fleet to maintain the dockyards, instead of the dockyards to maintain the fleet.

The means by which these places should be defended are by big guns above water; big mines below water, placed at proper distances in advance of the object to be defended. It used to be the fashion amongst professional men in this country to consider this latter mode of defence as being incapable of practical application, but of late years a very different opinion has prevailed; and through the efforts of Lord De Grey's committee we are now in a position to apply this system of defence to any extent that may be required for the protection of our harbors and other points upon our coasts. The question then arises, how far, if at all, does the use of the submarine mines affect the employment of forts and batteries for defence against naval attack. Forts and batteries are still required in all important cases to cover the torpedoes, and prevent their being tampered with. It must also be remembered that whilst the submarine mine is harmless unless the ship comes near it, the shot from the battery can injure the ship, whatever may be her position, within effective range. Further, although probably our harbors might be efficiently obstructed by torpedoes at from seven to fourteen days' notice, yet one condition is that the weather should be sufficiently favorable to allow them to be exactly laid. There are, again, certain positions where, even if the torpedoes were laid, they might be disturbed by a violent storm, and possibly an attack on the positions in which they were to serve might take place before they could be renewed; and although the periods of the year at which these difficulties might arise are short, yet the bare possibility of interference in the application of a complete torpedo system prevents our placing entire reliance on such a defence for the protection of places on which the warlike power of the nation, both for offence and defence, must in a great measure depend. Therefore, although submarine mines are a most important element in the defence of our harbors and coasts, and add greatly to the power of our forts to resist a naval attack, they must not be regarded as substitutes for permanent works of defence at our naval arsenals and harbors, and of our important forts.

To proceed now to consider the employment of big guns above water. These, with all the numerous accessories for their service, must be placed in positions so protected and arranged as to give them a decided superiority over the artillery of assailing ships. The question then arises, whether they shall be placed afloat in strongly protected vessels—*i. e.*, in floating batteries—or at fixed points either on land or on shoals—*i. e.*, in forts. It is often said, "Why don't you protect your ports by floating batteries alone?" The same reasons, however, as have been before adduced against the employment of our sea-going navy, prevent our employing special floating batteries for this object. It would necessitate our maintaining, at each of our chief ports, a naval squadron sufficiently powerful to resist the attack of superior forces of the enemy.

In the construction of coast batteries two main points have to be attended to: 1. To give cover to the guns and gunners. 2. To develop, as far as possible, the lateral range and rapidity of fire of the guns. These two principles being somewhat antagonistic, has so far always been one of those difficulties to be reconciled, and it is to the fluctuation in the relative importance of cover or fire, of protection for offensive power, that different designs for coast batteries are due. The simplest form of battery is a mass of material in front of the guns, and either of earth, masonry, or concrete, according to the circumstances of the site. It is evident that the greatest extent of range may be obtained from the guns if they are so mounted as to fire over this parapet—or, as it is called, *en barbette*—for their field of view is entirely unobstructed, and this simple system is well adapted for sites at considerable elevation, say 100 feet above the water, where neither the guns nor gunners would be much exposed to the fire of a hostile vessel. When, however, the site is low, the enemy's view of the guns in a barbette battery would be such that he would easily silence the battery; and it has therefore been necessary in such situations to mount the guns so that they may be fired through openings or embrasures cut in the parapets, instead of firing them over the parapet. The Moncrieff gun-carriage has solved many of these difficulties; but armored and covered defences are, nevertheless, essential under many circumstances, so that the fort might be protected properly from every species of attack.

The question of the defence of our great naval arsenals, in the event of an enemy obtaining a footing on our shores, was next discussed. It would, to say the least, be very unwise if we were to conclude that invasion is impossible because it is difficult. The best disciplined and the greater part of our military forces must obviously be employed to cover the capital; we must, therefore, arrange our plan of defence so that as few disciplined troops as possible may be necessary for the defence of other points in the country which must be defended, but which cannot be covered by the operations of the main army. A mistake is commonly made that because the arsenals and yards referred to are extensively fortified, the garrisons of those places must be largely increased. The case is precisely the reverse. Supposing all the outer line of forts to landward, at either Portsmouth or Plymouth, to be fully manned at the same time, (which would be quite unnecessary, not more than one-half need be fully manned at the same time.) only between 6,000 and 7,000 men would be required for the purpose at each place respectively, and only a very small portion of these need be regular troops. The remainder of the garrisons would consist of a movable force, which in any case we must have for the defence of these places, but which, in the absence of the forts, must be of sufficient strength and sufficiently disciplined to meet the enemy in the open field, whilst with the forts it may be comparatively small in number, and only disciplined to take up a fighting position, under the support of the works at that part of the fortified line assailed. Unfortified, an enemy would only have to detach from the main invading army about 15,000 or 20,000 men to effect, in a few days, the destruction of all our ships and naval establishments at Portsmouth. Fortified, he must employ an army of at least three times that number, and must have a considerable time at his disposal to undertake a regular siege. Unfortified, no force that, in the case referred to, we could afford for the garrisons of these places could protect either against the attack of 15,000 regular troops. Fortified, there is no difficulty in providing the numbers and description of troops that would be capable of making a good defence of these nurseries of the navy. Unfortified, they at once fall if an enemy were to obtain a decisive victory over the army in the field. Fortified, they remain in our hands even under such untoward circumstances, and thus enable us to avert the destruction of our naval power at a period when all the resources of the country will be required to enable us to retrieve the position we had temporarily lost.

We are often told that these works are unproductive, and so, in one sense, they are; but who shall say what effect permanent measures of defence may have upon the position of a nation. But we are met with other objections. It is commonly said that there is no use in constructing permanent fortifications, because the inventions of one age render useless the efforts of the previous generation. History, however, does not support this statement. At this moment we are turning to account, and with good effect, works erected by Henry VIII, more than three centuries ago. In like manner the works constructed in the time of Charles II, and in the reigns of George II and George III, all more or less form parts of the system of fortifications we are adopting at the present day. Then we are told that the measures are so extravagant. The fact, however is, that by the aid of fortifications we are enabled to defend the empire with fewer troops and a smaller navy than would otherwise be necessary, and that they thus tend greatly to economy. If we are to make provision for defence at all, it is only by the aid of fortifications that we can have an economical system of defence. They say, then, that our fortifications "lock up" troops. It has been shown, on the contrary, they enable us to utilize our auxiliary forces, and to set the regular army free. Again, we are told that we ought to depend upon our navy; but the main purpose of the fortifications is to enable the navy to do its duty effectively. The navy is, without doubt, the arm on which we must mainly depend; but that is no reason why we should tie it down to our side. Lastly, they say "an enemy will not go near these fortifications." The reply is, that that is the very object for which they are provided. To sum up, the truth is, that to provide an efficient system of defence at the least cost to the state, the soldier, the sailor, and the military engineer, must each occupy his proper place. The navy and the army are the vital principle of defence, and fortified arsenals and harbors are the centers of refuge and action for both. Take away fortifications, and you are unable to turn your auxiliary forces to proper account; you leave an army utterly insufficient for the duties it has to perform—a navy scattered, unsupported, and with no protected home.

DURABILITY OF STEEL RAILS.

It is officially stated that out of the eleven thousand tons of steel rails in use on the Hudson River Railway—some of which have been down over three years—only eleven rails had broken up to January 1, 1869.—One broken rail to the thousand tons, is rather a different matter from a thousand broken rails a month, which was the breakage of iron rails on the Erie road last winter.

On the Erie road it is officially stated that only ten steel rails have broken out of the eight thousand tons in use. Some thousand tons of the above mentioned steel rails were made at Troy—the rest are of English manufacture. The success of steel rails on the Lehigh Valley road is mentioned in another article.

The following letters from the President of the Philadelphia, Wilmington and Baltimore Railway give a complete history of the trial and use of steel rails on that road:

P. W. & B. R. R. Co., President's Office,
Philadelphia, Dec. 16, 1868.

Edward Austin, Esq., Boston:

Dear Sir—Your letter of the 15th inst. is before me. This company commenced the use of steel rails made at the Atlas Works, Sheffield, England, by John Brown & Co., in August, 1864. At present we have laid and have in use upon the most trying portions of our line, about twenty-five miles of single track of same make. We have never broken one in use, nor taken up one on account of wear or defect. In the middle of a much used portion of track laid with steel in 1864, near Philadelphia station, we laid one rail of American iron, and have replaced it, as needed, by other rails of American iron, until we have used up sixteen iron rails, while the steel will wear for several years yet. My last information as to condition of track, shows that not one steel rail in twenty-five miles of track shows any imperfection or defect, but all are wearing truly and smoothly. No observant passenger will fail to detect the passage of a train from steel to iron, and vice versa. I cannot speak of makes other than Brown's, nor do we fail to inspect his *rigidly.* I have rejected 88 tons from an invoice of 600 tons. Mr. Joy's* failures may have been of other manufacture. They may not have been well inspected; they may have been punched or slotted, or any one of many other good reasons may be adduced for their failure.—But my experience is enough for me. On a road like this, where our iron does not last seven years on an average, true economy, as regards the rail expenditure alone, demands steel rails. The reasons which limit our purchase of steel to about 50 per cent of our renewals, are found in our poverty alone.

We were long since led by our experiments to the conviction that punching and slotting were very injurious to steel rails, and for two years we drilled them as the lesser injury. We now use a joint fastening which dispenses with all holes in the rails.† My last purchases of Atlas rails were at $100 gold, in Philadelphia, to be delivered in 1869, and of Welsh iron rails, guaranteed five years, at $83 currency in Philadelphia. I have also received 100 tons Barrow steel on trial, and have a contract for 500 tons Pennsylvania Steel Company's rails. We have also in use 500 tons steel headed rails made in Pennsylvania,* costing $113 currency, which promise well. I am offered steel rails of other makers at $92 gold in Philadelphia, but have completed our purchases of iron and steel rails for 1869.

The freedom from a defect in a track means also diminution of cost of repairs of locomotives and rolling stock, and enhanced safety of passengers. If we go on laying ten to fifteen miles per annum in steel, you will ere long see that our expenses for track repairs and in our shops, will be reduced considerably. While we are buying steel rails and charging their cost to "repairs," that account must be large. * * *

Very truly yours,
(Signed) ISAAC HINCKLEY.

P. W. & B. R. R. Co., President's Office,
Philadelphia, Dec. 22, 1868.

Edward Austin, Esq., Boston:

Dear Sir—I have yours of the 18th. The first steel rail imported has already worn out sixteen (16) iron rails, and we have not now any reason to suppose that the latter invoices are of inferior quality. But there is great fear on my part, that railroad companies will themselves tempt steelmakers to send a poor article, by buying the cheapest—first cost only considered—as they did with the ironmasters. It rests with railroad men to keep steel rails good by buying no poor ones.

We try steel with the chisel for *hardness*, with the trip-hammer for *toughness*, and for *strength* with the 2,240 lb. drop, fifteen feet, the rail resting on supports three feet apart. Rigid inspection only can save us. Having passed inspection, make no holes, or at all events, no *punched* holes in the rails.—Punching is bad enough for iron, but death to steel.

We, on Friday last, dropped our 2,240 lb. "tup" twenty (20) feet, upon a steel rail resting on supports three feet apart. The rail was merely bent. I have in my office a steel rail twisted, *cold*, into a regular spiral of one entire turn to two feet length, without crack or flaw.†

Very truly yours,
(Signed) ISAAC HINCKLEY.

* Michigan Central Railroad.
† Reeves' new Joint.—*Ed. V. N.'s Mag.*

* Waterman & Beaver's puddled steel heads.—*Ed. V. N.'s Mag.*
† We have twisted rails made by the Pennsylvania Steel Company, and by John A. Griswold & Co., as here stated.—*Ed. V. N.'s Magazine.*

HISTORY OF DECARBURIZING IRON.*

No. II.

HEATING THE IRON TO BE MELTED, BY THE WASTE HEAT OF THE MELTING FURNACE —CAST IRON FURNACE FLOORS—HEATING BOILERS BY THE WASTE HEAT OF FURNACES.

Gardiner, Robert. — 1788, June 5. No. 1,608.

Printed, 3d.

Manufacturing iron and other metals by a progressively multiplying air furnace. A series of compartments connected by flues from the multiplying furnace, and the flame and heat pass from one to the other. Each has a separate door, the further compartment being less hot than the more near; the first may be at a welding, the second at a red heat, and the third at a less heat, or if required, may be raised to a greater heat by adding another and separate fire communicating with the common flue. The waste of putting cold iron into the melting furnace is avoided, as it may be heated by the waste heat in the extra compartments ready for use.

Cast iron floors for the furnaces save the wear of the old sand floors.

Steam boilers may be heated by passing the waste flame and heat from the furnaces, round, under or through them.

Note.—*The patent does not* SPECIFY *using the waste heat of puddling furnaces, but it* COVERS *such use, in as far as a puddling furnace is and must be a melting furnace. Jones specifies using the waste heat of puddling furnaces in* 1822. (Sec p. 359.)

This patent is only four years after Cort's invention of puddling. It mentions iron furnace floors for the first time.

It is remarkable in specifying, 81 *years ago, the heating of boilers by waste heat—a thing which is claimed by several modern mill managers.*

OXIDE OF MANGANESE USED IN THE CONVERSION OF PIG INTO MALLEABLE IRON.

Reynolds, William.—1799. December 6. No. 2,363.

Printed, 3d.

"Preparing iron for the conversion thereof into steel." The invention consists in the employment of oxide of manganese, or manganese, in the conversion of pig iron into malleable iron or steel. No proportions or details are given.

Note.—*This is the first mention of manganese in the Patent Office records of the iron manufacture.*

THE SQUEEZER.

Hartop, John. — 1805. November 7. No. 2,888.

Printed, 3d.

"Method of preparing malleable iron, &c." The invention consists in the use of a kind of squeezer worked by a cam instead of a forge hammer or rollers.

Note.—*This is the first mention of the squeezer in the patent records.*

INTRODUCING AIR BLAST ABOVE THE GRATE.

Dimmack, Jeremiah.—1812. May 26. No. 3,569.

Printed, 3d.

"Manufacturing iron in its difficult stages or forms of blooms, slabs, piles, bars," &c., "or other malleable iron from pigs or plate iron in a puddling, balling, bloom, mill, sheet iron furnace, or any other air furnace," &c. "Take any furnace of the common construction," but the grates must not be large, and "less at one end than the other." "Level with and immediately above the top of the grate," introduce an iron blast pipe, with stopcock to regulate and shut off the blast, and put dampers in the chimney.

Note.—*Although referring, among other things, to the manufacture of malleable iron from pigs in a puddling furnace, this practice, as far as it supplies air above the fire, would not meet the modern idea of puddling, viz: decarburizing by means of the fettling, without the aid of air. (See Siemens on Puddling, Van Nostrand's Mag., Vol. I, No. 1, page 37.) Blowing in air above the fire in reverberatory heating furnaces is, however, practised in some of our best modern forges, especially for heating large masses. This patent at least hints at this practice.*

IRON ORE, SCALES, LIME, ETC., USED TO DECARBURIZE PIG IRON.

Mushet, David.—1815. July 27. No. 3,944.

Printed, 4d

The metallic contents of refuse, such as slag, scoria, cinder, scales, &c., are recovered and made available for producing "finers' iron or metal" in a furnace, called "a smelting finery," by "making use of the superfluous carbon" in pig iron, which is to be melted with the refuse in the following proportions: 300 or 400 lbs. of coke, 600 lbs. of pig iron (broken up), 180 to 240 lbs. of refuse and 150 lbs. of limestone, or by preference, 40 to 120 lbs. of burnt lime. When the charge is melted, the metal sinks to the bottom, and should be kept carefully covered with the melted scoria; no part is to be run off till the furnace is tapped. If, after the first or second tapping, the metal is not sufficiently decarburized, or "not high enough blown," the proportion of coke is reduced, or that of refuse increased.

* We omit several patents clearly and fully anticipated in previous specifications. The specifications referred to are printed and generally illustrated with plates. We append the price to each. They may generally be obtained from the Patent Office in London, through any American publisher. Editions are sometimes out of print for a few months, but new editions are issued from time to time. Those referred to in our former article are all printed. The price is 3d. each, except Onions', which is 7d. All the British specifications and engravings are on file and free to inspection at the Astor Library in New York and at several other libraries.

2d. Instead of "refuse," iron ores may be reduced in a similar manner, with mixing them with pig iron, the ores being thus used for decarburizing the pig iron either in their raw state or calcined.

3d. Instead of the above charge, pig iron may be omitted, and 350 to 450 lbs. of coke or other fuel, 300 to 350 lbs. of refuse, and 100 to 120 lbs. of burnt lime, or 140 to 170 lbs. of limestone, melted together, will produce finers' metal. The proportion of lime should be with mill scale one sixth, mill or balling furnace slag one third, pudding and finery slag one fourth of their respective weights of burnt lime.

4th. To produce metal from iron ore, 300 to 400 lbs. of coke, 300 to 350 lbs. of iron ore (broken small), and as much lime as would flux the ironstone in an ordinary furnace, are used.

5th. With proper proportions of flux, refuse may be used either with ironstone or iron ore, care being always taken to have a sufficient depth of scoria to protect the metal. "By having a hearth of sufficient depth below the twyre, part of the scoria may be run off, and a greater quantity of metal be obtained at one tapping."

6th. If the materials of the charge are sufficiently fusible the quantity of coke or other fuel may be diminished, or the amount of refuse increased, till "the proper degree of decarbonation" is obtained. Waste is thus lessened, since "the higher the iron is refined or blown, the less is the loss or waste in the subsequent manipulations of the forge."

7th. The metal may be kept protected by a sufficient depth of scoria "by drawing off the metal from below," instead of "allowing it to flow off above," thereby requiring less blast.

The furnace recommended for the smelting refinery is similar to a common blast furnace, but smaller, with a square or cylindric hearth, having a height of about twenty to thirty feet, six to eight feet in diameter at the boshes, two to three feet diameter at the top; the hearth being five or six feet high, and two to four feet in diameter.

NOTE.—*At this time of excitement about the Ellershausen process and the ore processes it has given rise to, it is interesting to remember that both ore and other oxygen-bearing substances were specified, to partially decarburize pig iron, over half a century ago—not in the puddling furnace, but in a sort of finery or first stage of puddling. The use of the ores is clearly stated in the 2d paragraph above.*

PARTIAL DECARBURIZATION BY MEANS OF AIR JETS, WITHOUT THE USE OF FUEL.

HILL, ANTHONY.—1817. August 5. No. 4,151.

Printed, 9d.

"Improvements in the working of iron." These consist "in causing crude iron while in a fluid state, howsoever and from whatever substance such fluid crude iron may have been obtained, to be exposed to and conveyed along with a strong current of condensed air or blast in such manner that it may be thereby minutely divided and dispersed, and expeditiously "blown and acted upon by the air." The patentee describes an arrangement of apparatus by which this object can be effected. A cullender of cast or wrought iron shaped like a bucket, being about eighteen inches in diameter at the top, and ten inches at the bottom, is supported in a case on the top of a wrought iron tube about thirteen inches in diameter, and eight feet long, called the "discharge tube," which is sunk into a well surrounded with water to keep it cool. At the top of the tube just beneath the cullender are apertures for the admission of a blast. The operation is performed as follows: The molten iron is poured into the cullender and falls through the holes into the discharge tube. At the same time a strong blast is injected into the tube in and among the divided particles of iron, which are thus subjected to its action during their descent into the well. The iron is collected at the bottom of the well, and at the end of the operation the water is discharged from the well, and the iron then "must be made into bar iron by puddling, reheating and rolling, or by any other known means."

NOTE.—*Anthony Hill is known to have been a practical iron worker, but how far he utilized this invention we have no evidence. He does not propose to decarburize the metal sufficiently to make it malleable, as Martien subsequently (September 15th, 1855) did, by less adequate means, viz: the blowing of air up into a stream of liquid iron as it flows in a runner. Neither of these inventions could accomplish anything further than refining iron preparatory to puddling, and Hill's has this advantage over Martien's—that it would work—in some limited degree.*

Hill's is the first recorded proposition to decarburize without the use of fuel to keep up the temperature, and it would appear to anticipate the claims of subsequent inventions as far as partial decarburization, without the use of fuel, is concerned. Bessemer introduced a radically new element—the MECHANICAL FORCE OF AIR *to keep the metal subdivided so that the oxygen could act on a vast surface of carbon at once, and thus burn it* FAST ENOUGH *to keep the iron liquid.*

CHARCOAL USED TO PROTECT THE BOTTOMS OF PUDDLING FURNACES.

HARFORD, RICHARD SUMMERS.—1822. January 9. No. 4,634.

Printed, 3d.

"An improvement in puddling." The improvement consists in using a layer of charcoal or charred carbonaceous matter, powdered or otherwise, to "protect the cast iron bottoms or floors of puddling furnaces" from the effects of the intense heat, and substituting charcoal for the substances usually employed, such as scoria or sand, which impart injurious qualities to the iron.

HEATING THE IRON TO BE PUDDLED BY THE WASTE HEAT OF THE PUDDLING FURNACE.

JONES, WILLIAM.—1822. October 18. No. 4,713.

Printed, 3d.

"Improvements in the manufacturing of iron." The invention consists in charging the puddling furnace with refined metal, pig or crude iron in a heated state, instead of putting the charge in cold. The heating operation may be performed either by the heat of the puddling furnace or in a separate furnace.

NOTE.—*This patent is partially or wholly anticipated by Gardiner's, in 1788. This important improvement has long been used in some establishments, and is just now coming into very extensive use in this country. It is found to effect a considerable economy of fuel.*

THE USE OF SALT IN THE PUDDLING FURNACE.

LUCKCOCK, JOSEPH.—1824. May 15. No. 4,956.

Printed, 3d.

"An improvement in the manufacture of iron." The improvement is stated to be the use of salt in certain quantities, ascertainable by experience, to be mixed with the iron in the state in which it comes from the blast furnace, and worked up with it in the puddling furnace.

NOTE.—*Anticipated by John Payne, 96 years before, as far as the chemical effect of salt in refining is concerned, though not used in the puddling furnace. Experiments are still making, and patents are still applied for in this direction.*

THE USE OF SALT AND POTASH, IN SPECIFIED PROPORTIONS, IN THE PUDDLING FURNACE AND FINERY.

LAMBERT, JOSIAS.—1829. March 30. No. 5,779.

Printed, 3d.

"Making iron." The invention consists in the application of two parts salt and one part of potash, in the blast, or refinery, or puddling, or balling furnaces. The mixture being applied to iron of inferior quality at a high degree of heat, is stated greatly to improve it.

NOTE.—*Payne also proposed, in 1728, the use of potash; Lambert, however, is the first to specify definite proportions.*

SPECIFIED QUANTITIES OF SALT, POTASH, LIME AND SALTPETRE IN PUDDLING.

LAMBERT, JOSIAS.—1830. February 4. No. 5,893.

Printed, 3d.

"Making iron." The invention consists in the use of a mixture of salt, potash and lime, or a mixture of salt, saltpetre, and lime, in the smelting, or puddling, or balling processes, in all or any of them. The proportions recommended by preference are two parts salt, one of potash, and two of lime, for the first mixture, to be used when the iron is of red short quality, and for the second mixture, two parts salt, one and a half saltpetre, and two parts lime, to be used when the iron is found to be "cold short." The mixture may be introduced in the furnaces at regular intervals, or combined with every change of materials. The mixtures are used in proportions, varying according to the qualities of the iron. The following are recommended: In the blast furnace, 25 lbs. to the ton of iron; in the finery, 20 lbs. to a ton of iron; in puddling, 18 lbs. to the ton; in the balling furnace, 18 to 30 lbs. per ton.

WATER AND AIR CASINGS FOR FURNACES—THE BOILING PROCESS—DISPENSING WITH THE FINERY.

HORTON, DANIEL, and HORTON, GEORGE.—1832. September 7. No. 6,299.

Printed, 1s. 10d.

"Improved puddling furnace." The invention consists in applying to the old puddling furnaces certain additions claimed as new, viz: hollow vessels or cases forming the ends and sides of the lower part of the puddling furnace, allowing air or water to circulate in contact with the inside casing of the puddling furnace, the object being to enable a very high degree of heat to be used in the puddling furnace without its being destroyed, the injurious effects being prevented by the circulation of air or water carrying off the superfluous heat. The use of this puddling furnace (which is fully described with drawings) enables the refining process to be dispensed with. On the bottom and sides of the furnace are strewed slag and cinder to the depth of about an inch or an inch and a half. These are melted and form a bottom, on which are placed broken pig iron and $\frac{1}{4}$ by weight of cinder and slag. The whole is then "raised to a higher degree of temperature than is usual in puddling refined iron, which will cause the pig iron to boil," "during which operation the same is to be well stirred" by the puddler "until the malleable iron is disengaged from the cinder." The heat, if necessary, is then to be damped off. The iron is to be balled, and the puddling completed in the ordinary way; and when the balls are withdrawn, the fluid cinder is run out, and a fresh charge is put in. Malleable iron is thus produced direct from the pig.

NOTE.—*Water casings, backs and frames have been the subjects of many subsequent patents, new, doubtless, in detail; but here is the first record of the practice, and it is quite comprehensive and complete.*

Although commencing with pig iron is specified in former patents, the finery was universally used at this time as a preparatory process.

The boiling process was introduced, apparently, to avoid the finery—to decarburize faster. It is now used to make a better quality of iron.

A SHOOT TO CARRY MELTED IRON FROM THE BLAST FURNACE TO THE FINERY.

GUEST, JOSIAH JOHN.—1833, January 31. No. 6,379.

Printed, 3d.

The invention consists in affixing to the blast furnace an iron shoot or channel, and running the molten metal from the blast furnace direct into the refinery furnace (which is placed near thereto), where the iron is refined in the usual manner.

SPECIFIED QUANTITIES OF OXIDE OF MANGANESE, SALT AND CLAY, IN MAKING MALLEABLE IRON.

SCHAFHAUTL, CHARLES.—1835, May 13. No. 6,837.

No specification. See Repertory of Arts, Vol. IV, new series, p. 334; and Newton's London Journal, Vol. VII, p. 341.

"Manufacturing malleable iron." The specification of this patent appears to have been stolen.

From the following references (Repertory of Arts, Vol. IV, new series, p. 334; Newton's London Journal, Vol. VII, p. 341), it seems that the invention consisted in the use of black oxide of manganese, 1¾ lbs.; common salt, well dried, 3¾ lbs.; potter's clay, well washed, 10 oz. The ingredients are well mixed and ground fine, and fused with about 3¾ cwt. of pig iron in the boiling oven. The color of the flames will indicate the progress of the fusion. The mixture being, by preference, introduced in three portions, the result will be a good soft iron. To produce a harder iron, three or four shovelfulls of roller refuse and cinder from the balling furnace are added, and only half the quantity of manganese employed. Less quantities of manganese and more of refuse and slag will produce a harder iron.

NOTE.—*The use of manganese was first specified by Reynolds, in 1799. Schafhautl is the first to particularize proportions, which, by the way, are not very different from present practice in some localities. Manganese is now generally employed in the puddling furnace, in the shape of Franklinite pig iron, or spiegeleisen—the carburet instead of the oxide—and is found of great advantage when the irons treated are sulphurous. It is indispensable to making good puddled steel from most of our irons.*

PUDDLING WITH THE USE OF PULVERIZED IRON ORE.

MUSHET, DAVID.—1835, October 22. No. 6,908.

Printed, 6d.

"Manufacturing bar iron or malleable iron." The specification commences by giving a detailed account of the refinery and puddling processes, and the terms employed therein, and of the different qualities of cast iron. It then proceeds to describe the improvements patented, which consist in mixing finely-powdered iron ores of rich qualities with the iron while being puddled in the puddling furnace. Sometimes powdered charcoal is mixed with the powdered iron ores. The mixture is added in small doses, and promotes the fermentation of the iron, and causes it sooner to be "brought to nature." It also enables crude iron to be used without being refined, and produces a bar of improved quality and greater weight than the old processes. A charge of about 450 pounds of crude pig iron, varying in quality from bright grey and mottled to white, according to circumstances and the judgment of the manufacturer (No. 2 grey iron foundry metal will produce excellent bar iron) is employed; when it begins to melt, and is fit to be stirred by the puddler, a dose of about two pounds of powdered ore, or ore and charcoal, is sprinkled on the iron, and well stirred up with it. The doses are gradually repeated as they are absorbed, until about forty pounds of powdered ore (or one-eleventh by weight of the charge of crude pig iron), have been sprinkled on the fermenting iron. The puddling process is carried on meanwhile in the usual way. If charcoal is mixed with the powdered ore, it should be wetted. By this process, about twenty hundredweight of puddled bars are produced from twenty-one and a half hundredweight of crude pigiron of as good quality as would be obtained from ordinary refined metal. If refined metal or "plate" be used instead of crude pig iron, to a charge of 450 pounds about twenty-five pounds of powdered ore should be used, and twenty hundredweight of puddled bars are produced from twenty and three-quarters hundredweight of refined metal or plate. Other proportions and particulars are given according to the quality of the materials employed.

NOTE.—*David Mushet was the very best authority on the iron and steel manufacture at this time. Like other men of large ideas and experience, he sometimes patented or suggested very novel changes, which, although very reasonable, also, had not been worked out in practice. In this case, however, his specification was obviously drawn up after the facts had been fully developed.*

Thirty-four years ago, Mushet published the fact that stirring fine ore into iron during the process of puddling IMPROVED THE QUALITY AND INCREASED THE YIELD—*a fact that some of our iron makers have not yet found out. Coarse ore for fettling has long been used, especially in the works about Troy; but the practice is not so common in Pennsylvania and the West. Indeed, the Troy iron makers consider the Ellershausen process a greater improvement on the Pittsburg practice than on their own. But stirring in fine ore has just begun to be practiced regularly. Mushet specifies about 10 per cent of ore; as much as 30 per cent (what Ellershausen uses) has lately been used in the puddling furnace during a fortnight's steady work, with a very great economy of fuel and time, and with an improvement of quality.*

Some 20 years ago, the experiment of mixing charcoal with the ore, as here suggested by Mushet, was tried at a large American works with very good results. The practice has lately been revived. The use of carbon to aid decarburization can be explained on the ground of promoting a higher heat throughout the mass. The more carbon there is in Bessemer pig iron, the more easily is it removed; the rapidity of combustion is the great end to be sought.

A good many inventions are from a quarter to a half a century ahead of the times. The Stevenses, of Hoboken, developed or suggested nearly every feature of modern iron-clad warfare twenty years before they were taken up by Governments. In fact, Col. John Stevens made drawings of an iron-clad ship for the defence of New York in 1812, which was 43 years prior to the first use of iron-clads in naval warfare. Mr. Mushet was equally in advance of the times, not only in his practice mentioned above, but in other directions to which we shall have occasion to refer.

MECHANICAL PUDDLING.

SCHAFHAUTL, CHARLES.—1836, June 13. No. 7117.

Printed, 9d.

"Apparatus for puddling iron." The specification and drawings describe an apparatus for working the stirring rabble, and giving it the necessary longitudinal and transverse motions in the puddling process.

NOTE.—*Considering the fact that this process is likely to come into use soon in this country, these old patents (this is the first record on the subject), are likely to be interesting, and we commend their perusal to the one hundred and one geniuses who will apply for rabble moving contrivances as soon as the thing is likely to be in demand.*

THE DRYING OF PAINT.

From a paper by Charles Tomlinson, F. R. S., read at the Society of Arts.

(Continued from page 261.)

Every one knows what is expected of good paint. In the first place, it should be sufficiently liquid to spread under the brush, and sufficiently viscous to adhere to the surface, even though it be vertical, without running, or becoming unequally thick in different places. In the second place, it should become solid within a reasonable time after being applied. Thirdly, the solid should adhere strongly to the surface.

We have seen that lead and zinc paints become solid by the absorption of atmospheric oxygen. But as pure linseed oil also becomes solid by exposure to the air, the drying of the paint is not due to the presence of a dryer, or of the oxide of lead or of zinc. It is true that the dryer acts by increasing the absorptive power of the oil for oxygen gas. The lead and zinc oxides have also drying properties, and we must not neglect the influence of the surfaces that are to be painted. Paint dries at different rates on glass, wood and metal; it dries better on some kinds of wood or of metal than on others, of course under similar conditions of experiment.

Drying on Glass.—Surfaces of glass were coated with linseed oil, also with the oil containing a little white antimony, and with the same compound with the addition of a little litharge. The linseed dried quickly, the antimony compound not so quickly, while in the third compound the presence of the litharge seemed to neutralize the retarding effect of the antimony. The following table shows the results:

	Linseed oil.	Linseed oil and oxide antimony.	Linseed oil and litharge dryer and oxide antimony.
	Days.	Days.	Days.
First coat dried in...	17	26	21
Second coat dried in..	17	8	9
Third coat dried in...	9	9	2
Total	43	43	32

It appears from this table 1. That a glass surface does not allow the paints to solidify so readily as a surface formed of the solid oil or paint. 2. That the antimony oxide is antisiccative, which effect is corrected by the litharge. 3. That in the second coat the glass seems to be still exerting a retarding action on the oil, but this is not so evident in the antimony paint. 4. That the influence of the litharge dryer is evident in reducing the time required for the drying of the third coat. This influence seems to depend not only on the presence of the litharge dryer in the viscid paint, but also on its presence in the solid surface on which the fresh paint is laid.

Drying on Oak.—The influence of the kind of surface employed on the drying of paint is well shown in the case of oak. On oak surfaces stained brown, three coats of linseed oil took forty-six days to dry, oil with a litharge dryer seven days, oil with a manganese dryer still less time. It was also found that linseed oil and white lead and linseed oil and white zinc dried more quickly with a manganese dryer than with a litharge dryer. On a surface of clean oak the first coat of oil took a very long time in drying. On the twenty-second day it was soft and pasty beneath the surface; the oil had sunk into the pores of the wood, and thus prevented it from absorbing the oxygen required for its solidification. This explains why oil dries more quickly on a painted wooden surface than on a porous one. On a porous surface the dryers seem to act with great effect, probably from covering the wood and preventing the oil from sinking into the pores. Their influence is shown in the following table:

	Linseed oil and white zinc.	Linseed oil and litharge dryer and white zinc.	Linseed oil and manganese dryer and white zinc.
	Days.	Days.	Days.
First coat dried in...	66	6	5
Second coat dried in..	6	5	3
Third coat dried in...	6	5	3
Total	78	16	11

This also shows that a surface of linseed and white zinc allows the paint to dry much more rapidly than a surface of porous wood does. A similar effect is produced when the paint is laid on an old surface of paint. The paint itself also becomes more siccative under the influence of time and atmospheric exposure.

It appears from experiment that paint dries more quickly on poplar than on oak, and more quickly on pine than on poplar. In the experiments on metallic surfaces the most remarkable results were obtained on lead. The first coat of linseed oil dried very quickly on this, as also the first coats of lead paint and of zinc paint. The zinc paint dried first, then the linseed oil, and lastly the lead paint. The zinc paint, however, tended to retard the drying of the subsequent coats. A newly scraped surface of lead acted more energetically than one that had been tarnished by exposure to the air, but the lead covered with one coat lost its influence in hastening the drying of the subsequent coats. The first coat of oil on bright lead was only ten hours in drying. In short, we get this remarkable result, that lead is siccative with reference to pure linseed oil, while white lead itself, a siccative body, is anti-siccative with respect to linseed on metallic lead.

Summary of Results.—The influence of various metallic, vitreous and wooden surfaces is thus summed up by M. Chevreul:

First Coat—*On Copper.*—Oil dried more slowly than both oil and white lead, and oil and white zinc.

On Brass Wire and Zinc.—Oil dried as rapidly as oil and white lead, but more rapidly than oil and white zinc; but on the brass wire the drying was more rapid than on zinc.

On Iron.—Same results as on zinc; but oil and white zinc dried more quickly on iron than on zinc. This is analogous to the fact noticed with lead. The oil and white lead dried more slowly on lead than did the oil and white zinc.

On Porcelain and Glass.—Oil dried a little more quickly than oil and white zinc, and oil and white lead a little more quickly still.

On Plaster.—The oil and white zine paint dried in about equal times.

On Poplar and Mountain Ash.—Oil dried more slowly than oil and white lead, and also than oil and white zinc.

Three Coatings—*On Copper, Brass Wire, Zinc, Iron, Lead.*—Oil and white lead dried more quickly than oil and white zinc. This was also the case on porcelain, glass, plaster, poplar, and mountain ash. In the case of the woods, linseed oil was found to dry more quickly on ash than on poplar, and more quickly on poplar than on oak.

Effect of Temperature.—Some of these surfaces may, however, be regarded as indifferent, as respects their influence in quickening or retarding the drying of paint; but the temperature and other circumstances modify any general conclusions that may be drawn on the subject. Paint dries more quickly at from 77° to 82° Fah., than from 59° to 64° Fah., other things being equal. This explains why, in practice, the proportion of dryer varies with the temperature. In winter it is customary to add from three to nine, and even ten per cent of dryer to the linseed; in summer not more than half, one and a half, or two per cent, and it may even be left out altogether in the last coat.

Effect of Dryers.—The drying property of linseed oil is nearly always increased by the addition of white lead, and in most cases by that of white zinc. If the compound be not sufficiently siccative, it can be made so by the addition of a dryer, whether of litharge or of manganese, due respect being paid to the varying conditions of the surface, number of the coats, whether first, second or third, temperature of the air, and the amount of natural light present. But the influence of the lead or manganese dryer, as will be gathered from the foregoing details, is not so important as is generally imagined. It can be dispensed with in the second and third coats, and even in the first if the temperature of the air be favorable. Linseed oil by exposure to light and air loses its yellow color and becomes siccative, so that it can be employed alone with white lead or white zinc without detriment to their purity. If white zinc be associated with the sub-carbonate of zinc, the dryer may be dispensed with altogether.

Lustre of Paint.—Paint owes its lustre and smoothness to the oil alone. If oleic acid were mixed with metallic oxides in such proportions as to form solid chemical compounds, and the acid were to pass quickly from the liquid to the solid state, the result would not be a smooth, uniform oleate; but when the drying oil passes slowly into the solid state, in consequence of the gradual absorption of oxygen, and the changes pointed out by Mulder, the very slowness of the process allows the oily molecules to arrange themselves into a symmetrical compound, which would be transparent were it not for the opaque particles of the white lead imprisoned in the compound. If these opaque particles are not in excess, the molecular arrangement is such that the paint dries into a surface that is lustrous, and even brilliant, in consequence of the mirror-like reflection of the solidified oil.

EFFECT OF TURPENTINE.—This substance is added by painters, in order to diminish the viscosity of the paint, and to allow it to spread more easily under the brush. If the surface is to be polished, a large proportion of turpentine is used; if it is to be varnished, as much turpentine is added as will render the paint very fluid, but not too fluid to work with; if the paint is to be very durable, and it is to be neither polished nor varnished, only a small proportion of turpentine is to be added. As turpentine dries to a great extent by evaporation, one of its chief uses is to hasten the drying of paint. Thus, three layers of linseed oil on glass dried in twenty-five days; but when about thirty per cent of turpentine was added to the oil, the mixture dried in twenty days. This drying effect is promoted by a previous exposure of the turpentine to the air. When both oil and turpentine have been previously exposed, the drying takes place still more quickly. Exposure to air has a similar influence on the other ingredients of paint, even on the white zinc.

OTHER DRYERS.—This exposure in the case of turpentine favors the combination with atmospheric oxygen and the consequent resinification of the liquid. Exposure in the case of a porous body like white zinc may also lead to the physical absorption of oxygen, and thus hasten the drying. If this physical effect were really obtained in the case of white zinc and white lead, Chevreul thought it likely that the presence of other solid bodies in the paint might have a similar effect. But before putting them into the paint, their influence as surfaces was tested. When linseed oil was laid on white lead, three coats dried in seven days; but on sulphate of zinc they occupied eighteen days in drying, twelve being required for the first coat and two for the second; white lead is therefore more siccative than the zinco-sulphate. In both cases the first coat acted as a dryer to the second. When a mixture of sulphate of lead and white lead was used as the surface, the oil dried almost as quickly as on white lead alone. It has already been shown that the addition of the litharge and manganese dryers made the linseed oil dry more quickly; that is, it became more capable of absorbing oxygen from the air. It is remarkable that this absorptive power is increased by the addition of solid bodies, such as sand. Linseed oil mixed with white lead dries more quickly than the oil alone, so that white lead is a dryer or siccative. Oil mixed with sulphate of lead dries very slowly; but a mixture of oil, sulphate of lead and white lead, dries as quickly as oil mixed with white lead only. Hence the presence of white lead confers extra drying power on sulphate of lead. Carbonate of zinc acts as a dryer, when added to oil or white zinc; and the mixture dries more quickly than oil mixed with white zinc only. Oil mixed with zinc carbonate sets more rapidly than with zinc white; but it forms a semi-transparent, not an opaque paint. As zinc carbonate renders oil and white zinc more siccative, it might be substituted for the manganese dryer, which has the disadvantage of imparting color to zinc white. Two paints were prepared, one consisting of 100 lb. of linseed oil, 75 lb. of zinc white, and 25 lb. of zinc carbonate; the other of 98 lb. of the oil, 2 lb. of the manganese dryer, and 100 lb. of white zinc. With each of these paints a door was painted. Four hours after they had been applied both paints appeared to be equally set; but the surface coated with the first paint was whiter than that coated by the second; the whiter paint was, however, the less adherent.

ECONOMICAL RAILWAYS.

AMERICAN FEATURES — THE NARROW GAUGE — IMPROVED LOCOMOTIVES — WELL FILLED TRAINS.

The interest of the profession and the public, in this subject, is on the increase, especially in England. Although at the first glance the idea of light, cheap railways, seems an approach to the American system, yet upon investigation it will appear that only one or two features of construction and working, that are distinctively American, are advocated for the guidance of English constructors and managers. Let it be always and distinctly understood that the "Light Railway" movement in England is not an indorsement, in any degree, of the American counting-room system of *bad* railways—poor iron, cheap machinery and rough roads. On the contrary, the improvement of locomotives, running gear and permanent way, are among the chief features of the proposed reform.

The features that might be called American, as proposed for new British railways, especially in the rural and mining districts, are, first, following the surface of the ground —going over and around hills rather than through them—up to certain limits of curvature and gradient, say one in 40 and five chain curves; second, the use of a single track worked by telegraph; third, filling the trains with paying load. In these respects even we might improve. But in the other proposed economies we need as much instruction and reform as the English, viz: in the narrow gauge for branch lines of light traffic, and especially for under-ground city lines, where every additional foot of surface bought, and cutting made, tells largely on the cost; and in a better system of running gear for all lines; in articulated rolling stock, and in the utilization of weight for adhesion.

In a former article* we considered the excessive and unnecessary cost of English lines—a cost made up of parliamentary expenses, land damages, and heavy earthworks and engineering structures, to secure straight, level roads. We now propose to consider some other features in the proposed reform, compiling from the standard authorities before quoted: First, the use of single lines.† These, if worked by telegraph upon the block system would be equally safe, and in all respects as sufficient as double lines. It would be an active traffic that required twenty-four long and well filled trains each way daily, yet this is but one an hour in each direction, so that the rails of every mile of a double line would be unused for about twenty-three hours of the twenty-four. A proper adjustment of trains, proper care, and the indispensable aid of the telegraph, render a single line as safe as a double line, it being understood that the trains are not so numerous as to exceed say two each way in the hour. The extra cost of a second line of way, including extra width of cuttings, embankments, viaducts and tunnels, cost of land and cost of permanent way, cannot be taken as much less on the average of English lines than £5,000 per mile, upon which the interest charge at five per cent is more than 1s. per train mile for eight trains each way daily, these trains easily accommodating a daily traffic each way of 1,000 passengers and from 500 to 1,000 tons of goods. Single lines form the majority of the Prussian railway system, which is worked with fewer accidents than almost any other in the world. The single line system in the United States, when worked by telegraph, has not proved unsafe; the greater number of "accidents" on these roads resulting from bad construction and attendance.

The narrow gauge is advocated by various authorities, among others, Mr. Hulse,* as follows: There are strong reasons for preferring the 3½ft. to the 4ft. 8½ in. system for local railways. The rails of the former do not exceed 40lb. to the yard; tunnels and bridges of a height not exceeding 10½ft. may be employed; open cuttings of much smaller dimensions; and curves may be used of a radius of only two chains, the locomotive engines need not exceed 15 tons weight; carriages 5 tons weight; and on no driving wheel would there be more than three tons. Whereas on the 4ft. 8½in. system the rails are 80lb. to the yard; tunnels and bridges 24ft. wide, 16ft. high; open cuttings in proportion; curves not less than eight chains radius; locomotive engines, 30 tons weight; carriages, 8 tons; minimum load upon each driving wheel, 6 tons. The short curves admissible on the narrow guage avoid to a great extent the destruction of property, villa residences, etc.; that is in passing by, instead of through them. The minimum radius of the curves and minimum height of headway admissible in each system are the most important features to be considered in deciding upon the best system of railways for towns which have canals, rivers, existing railways, a labyrinth of sewers, gas and water pipes ramifying throughout. Another important feature to be considered, of course, is the question of cost. The 3½ft. system, it is estimated, will cost less than two-thirds as much as the 4ft. 8½ in. system, and may be worked at a correspondingly small expense.

It may be asked why not adopt a 3ft. or even narrower system. The answer is that the 3½ft. system is already largely adopted in Queensland, Ceylon, Norway, Belgium, and other places, and with complete success. In designing the carriages for the local line, the 3½ft. gauge is found to give ample accommodation. The carriago which promises to be most suitable is what may be termed of the omnibus type, with seats arranged on each side and a longitudinal passage, say

* Van Nostrand's Magazine, Vol. I, No. 3, p. 243.

† See also a list in the "Railway Notes," on a following page, of particulars and results of narrow gauge lines.

*Address of Mr. W. W. Hulse, President, before the Manchester Institution of Engineers.

30in. to 36in. wide down the middle, with doors opening inward at the ends. The leading dimensions are 20ft. long, 6ft wide, and 6½ft. high inside. Carriages of this size would accomodate 24 passengers, twelve on a side, and give over 30 cubic feet of space to each. It might indeed be found desirable to adopt even a 2ft. gauge in some districts for cheapness, as has been done in North Wales, where the Festiniog Railway has a gauge of 23in., locomotive engines under 8 tons weight, and over this railway of thirteen miles in length, were carried in 1865, 2,500 passengers, 11,000 tons of general merchandise, and 90,000 tons of minerals, yielding a profit, it has been stated, on the capital outlay of 26 per cent.

Another authority says on this subject: As a rule, we are not favorable to the adoption of narrow, or more properly, small gauge railways; they appear, as it were, to constitute a bar to the future development and extension of commerce and traffic. We would greatly prefer to witness a large and important undertaking, designed and executed upon a scale somewhat exceeding the proportions actually necessary, than to witness it carried out in a manner that barely sufficed to meet the exigencies of the moment. There is a medium between building for posterity—between concerning ourselves about the probable state of our coal fields after the lapse of half a dozen centuries—and constructing works so that they should be, in the main, capable of answering their intended purpose for the next fifty years. To each generation belongs its own duty of construction, reconstruction, demolition and alteration, and it is unjustifiable to incur a heavy extra expense in order that "a thing may last for ever." Are we, then, awaking to the conviction that we have spent millions upon railways in endowing them with properties that are self-destructive? One of the reasons influencing Brunel in his recommendation of the seven feet gauge was, that by thus enlarging the base of the rolling stock, increased stability would be obtained, and a speed ensured higher than that which would be compatible with safety upon a narrower track. Time has shown this reasoning to be fallacious; the trains upon the Great Western do not run faster, or, practically, with greater security than those upon other lines. Similarly, by its own supporters, the 4 ft. 8½ in. gauge was considered the narrowest that could be employed with safety, bearing in mind the great velocity that was expected would be ultimately attained upon it. It is needless to mention that the velocity anticipated never has been attained on either of the gauges. Both Stephenson and Brunel, it is well known, contemplated the probability of running trains at a speed of a hundred miles per hour, whereas the average maximum reached is barely half this amount, and the minimum is something less than what was the usual pace of the old "fast coach." It must not be understood that we consider this conclusion (favoring a narrower gauge) to apply to all our railways. A line similar in extent and importance to the London and North-Western, constructed upon a gauge of three feet or three feet and a half, would be a miserable failure, but a double line upon a similar width of track, to convey the coal traffic from Newcastle to London, might not only present a different appearance, but prove a very remunerative speculation.

We have too long adhered to a false system of locomotive construction. While greatly overloading the driving wheels of our engines, we throw away from one-half to two-thirds of the total adhesion weight. We also make needlessly large driving wheels, often employing 6½ft. to 7½ft. where 5ft. to 6ft. would answer the fair requirements of traffic, and permit of smaller cylinder and less weight of working machinery. We can see no solution of the problem of economical locomotives except in the double bogie system. In these almost any length of total wheel base may be had without straining the way or inducing excessive friction; the weight is equalized on all the wheels and the weight per wheel kept down to 4 or 5 tons, instead of, as is now often the case, 7 or even 8 tons. Fairlie's engines are also rid of the burden of the lumbering tender, a great 12 or 14 ton monstrosity, with the additional weight of, say, a ton of coal, and from 5 to 10 tons of water, water which should be "picked up," in quantities of one or two tons only at a time, as wanted, from Mr. Ramsbottom's troughs. A double bogie tank engine having eight 5ft. wheels, and weighing but 36 tons, the wheels driven by two pairs of 14 in. cylinders, with a stroke of 2ft., would, with a very moderate steam pressure, pull a train of a gross weight of 300 tons up a two mile incline of 1 in 60, at the rate of 20 miles an hour, a work corresponding to nearly 800 horse power, during the six minutes of the run, in thus surmounting an elevation of more than 175ft. Such engines, without excessive total weight, would have a power sufficient to deal easily with trains of much greater weight than the present, upon gradients and through curves seldom met with on our own old, costly, "first-class" lines.

A farther economy should consist in running fewer, slower, and better filled trains, thus dividing the expenses per train among a greater number of passengers or tons of goods in that train. It was not long since stated that the London & North-Western, Great Northern, Great Western, and Midland Railways together run fifty-two passenger trains daily between London and Manchester! So far as through traffic is concerned, three or four each way daily should serve every reasonable requirement. Railway promoters and engineers must yet awake to the fact that the most profitable and useful railways are those made and worked for the great paying lower class, as distinguished from the far less numerous and far more fastidious upper class. The former do not require either very fast or very frequent trains. An excursion train shows with what they are willing to put up. And a thousand passengers in a train, paying each a farthing a mile, £1-0-10 per train mile, is about the most profitable load an engine can draw, unless it be a bullion train, paying, it may be, £4 or even £6 per mile, as has been the case on the South-Eastern line.

In cases, however, where there is a large and constant stream of passengers, railway carriage can be cheapened enormously, with abundant remuneration to the carrier. We can best illustrate this by contrasting the fares on the Metropolitan Railway with those which are charged and found quite unremunerative upon country branch lines. From Notting-hill to Moorgate-street and back, a distance of twelve miles, first-class passengers are carried for 1s.; second, 9d.; third, 6d.; being at the rates of 1d., and $\frac{3}{4}$d., and $\frac{1}{2}$d. respectively per mile; yet that line cost an average of over £500,000 a mile to construct. But on a branch country line, the rates may be 3d., 2d., and 1d., a mile, and the cost of the line only £10,000 per mile, yet no remuneration will be obtained.

Land damages are often a most unjust tax upon railways and the public. It should require no parliamentary contest to make a railway more than to make a highway or to open a street. And so far from landowners being "compensated" at extravagant rates, the benefits, generally very great, which railways confer upon their property should be considered and taken into account. The eight acres of land taken for a mile of railway may be worth far less, valuable though it be, than the benefit which the railway itself confers upon the adjacent hundreds of acres. The question arises, are new cheap lines required on routes where the present costly lines exist. The older lines were constructed at immense cost for a speed for which a great majority of the public are unwilling, if not unable, to pay. And it does not answer the question nor the purpose to say that they can have as slow a speed as they choose on the existing lines. So they might; but, unless the great capital charge upon these lines is in part sacrificed, the slow speed will not after all be a cheap speed to the passengers. Unless the companies are prepared to do this—and it is certain that they are not—the public have a good right to call out for free trade in railways. Even a war between competing companies would be for the time to the public benefit, and it is certain that the company having the smaller capital burden would have the advantage in any contest. Its line may have steeper gradients and sharper curves, involving a somewhat greater charge for locomotive power and maintenance of way; but there would not be the long tunnels, the lofty viaducts, the grand metropolitan approaches, and the magnificent termini to pay interest upon.

In conclusion, it is tolerably certain that, with the cheaper lines and more economical mode of working, taken together, nearly one half of the present rates of fare might be saved. Such economy is not without precedent. English "railway men" are mortified to read in our Continental Bradshaw as follows: "The railway system (of Belgium) was adopted as early as 1833, and at the present moment no country in Europe is better provided with railway accommodation than this industrious and prosperous land. There is not one town or village of any importance without its railway communication. The fares are lower than in any other country; for long distances not exceeding $\frac{1}{2}$d. a mile first class, $\frac{1}{3}$d. second class, and $\frac{1}{4}$d. third class—one-fifth of the rate charged in England." Yet the Belgian lines are profitable to the state, and that too, nothwithstanding that all the elements of necessary cost, whether of construction or working, are as great as in England, excepting only the cost of labor, and the salaries of officials. There is no difference, in principle, between the English and Belgian systems of railway construction, nor in the rolling stock employed.

DIRECT ACTING STEAM PILE DRIVER.

SYSTEM PATENTED BY M. J. CHRETIEN, PARIS.

Translated from "Le Génie Industriel."

In order that pile driving may be effected rapidly and economically, certain conditions must be satisfied, the chief of which we will indicate. Of the first importance is the rapidity of the blows; next to that is the weight of the ram, and lastly the height of the descent. At first, it might seem that with a given fall and weight of ram, the number of blows would be the same, whether struck at long or at short intervals. Practice, however, shows the reverse of this to be true, and it is not difficult to account for the difference in the two cases. For example, it might be necessary under certain circumstances, to give 100 blows at the rate of four or five per minute, in order to sink a pile to a given depth, while it is well known that at the rate of fifteen or twenty blows per minute the amount of drift would be considerably greater; in other words, fewer blows would be required to produce the same result. The difference is such that in certain soils the results might vary in the ratio of one to two. It is easy to see that if a pile, which has received a series of blows, is allowed to remain undisturbed for a sufficient length of time—or possibly only a few minutes—the earth which has been forced aside by the entrance of the wood settles back around it, and ultimately sets. The result of this adhesion is an increased resistance to driving. But if the blows are repeated very rapidly, the earth, which is more and more thoroughly displaced by each successive stroke, has not time to settle back or to adhere. The pile is, as it were, sunk into a hole in the ground, and the work is but little more than that requisite to drive the point. These effects are most decided in soft ground, in sand, and in works under water. Heretofore, in prescribing the weight of the ram and the number of blows, engineers have merely indicated the point at which the pile refuses to sink lower; but in view of what has been said we think they should no longer neglect the time during which the blows should be given.

The weight of the ram is of considerable consequence, but its importance should not be exaggerated, especially when it is possible to regulate the fall and velocity. A heavy ram, falling from a great height, gives a powerful shock, but beyond certain limits the effect produced ceases to be proportional to the weight, and besides, there is the disadvantage of exposing the pile to splintering, which should by all means be avoided. Any weight in excess of 1,000 kil. is injurious rather than useful, and in general it is not advisable to exceed 800 kil.

The height of the fall is the most variable element, and the best driver is the one which will strike both light and heavy blows with rapidity. There is no minimum, since in some cases it is necessary to begin by striking as lightly as possible; but there is a maximum, for no part of the force of the blow should be expended in splintering or even in sensibly altering the wood. A descent of five meters is the greatest which it is well to employ when the blows can be struck rapidly enough.

The pile driver invented by M. Chretien completely satisfies the conditions just laid down. It is constructed upon the general plan which that engineer has already applied to direct acting cranes and lifts. Its simplicity is such that all deterioration is well nigh impossible, and its maintenance is most economical. By comparing it with the direct acting steam-crane just mentioned, or with the steam-hammer, it will be seen that it is practicable to strike very light blows, and also to strike rapid ones up to a blow per second. The rapidity of movement should be limited only by the boiler power, which should be proportioned to the work which it is desirable to accomplish in a given time.

[The most important peculiarities of this machine are, first, the peculiar method of applying the power to the weight. The chain passes from the ram over a grooved roller at the top of the guides; thence downwards around a second grooved roller, situated in a frame attached to the end of the piston-rod; thence upwards again over two more rollers at the top of the guide-frame, and finally is made fast around a windlass within reach of the engineer. Second, the steam cylinder is of great length—equal, in fact, to one-half the extreme rise of the ram—and works nearly vertically. The mechanical principle involved in raising the weight is that of the pulley in its simplest form; the power being applied *between* the two ends of the chain, and the weight being at one end. Hence the rise of the weight will be twice the amount of movement of the piston.]

The workman who manages the driver has only to move a single lever, and each movement of the hand corresponds to a blow.—As fast as the pile sinks he unwinds the chain from the windlass, thus regulating the fall by the depth to which the pile has been driven. At the same instant he lowers at pleasure the wedges which limit the rise of the ram, and all without loss of time.

There are two ways of driving with this machine—first, by not loosening the ram from the hook, in which case the block descends with the grapnel and chain, and strikes lightly and rapidly; second, by long descents, in which case the ram, arriving at the top of the slides, detaches itself, falls, and is raised as soon as the grapnel takes a new hold.

Finally, the same maneuver serves for putting the pile in position (*à la mise en fiche*). Unwinding the chain from the windlass and fastening the grapnel directly to the pile, the mechanic draws it in by a few strokes of the piston and by reversing the windlass.

It was at the works undertaken by the city of Paris near the Pont de l'Alma that this pile driver was first tried. Its success has been so satisfactory that the engineers and contractors who have observed its workings have ordered them.

MODERN ENGINEERING.

It would be difficult to condense Mr. McAlpine's excellent paper on this subject, lately read before the American Institute. The following points, however, are of peculiar interest:

Since 1829, the locomotive has increased from four to 40 tons in weight, and from fourteen to 60 miles per hour in speed. Then grades of 50 feet per mile were the maximum, now those of 440 feet at Mont Cenis and 528 on the Baltimore and Ohio, have been used. Forty years ago Horatio Allen had to mount the foot-board of our first locomotive himself, now 15,000 are daily whirling over 40,000 miles of railways in this country alone.* The Erie Canal, originally built for vessels of 60 tons, has just been enlarged for those of 250 tons, and its increasing traffic already demands an enlargement for vessels of 1,000 tons. Of the traffic of the great West it now carries more than all of the great trunk lines of railway between the St. Lawrence and the Potomac. One canal boat carries more tonnage than a freight train, and the Erie Canal brings daily to tide water more than five times as much tonnage as the New York Central. Its tonnage exceeds that of all the foreign commerce of New York. The materials used in its construction exceed in quantity those required for the 2,000 miles of the Pacific Railway.

The Niagara and Cincinnati wire suspension bridges by Roebling; the Havre de Grace bridge, of wood, by Parker; the Schuylkill bridge of cast iron arches, by Kneass; and the Victoria iron girder by Stephenson, are among the most noted bridges. In submarine works in this country, the most remarkable are the piers of the Potomac and Croton aqueducts, of the Havre de Grace and Harlem bridges, and the founding of the United States Graving Dock, at Brooklyn. The aqueducts and graving dock were founded by means of coffer dams, the Havre de Grace bridge by means of iron caissons, and the piers of the Harlem bridge are composed of large cast iron columns or hollow piles, driven by the newly discovered pneumatic process. A mass of metal of a ton weight was unknown before the Christian era. Now those in cast iron up to 150 tons, in wrought iron to 40 tons, and in steel or bronze to 25 tons, are made in any desired forms, and turned or bored with the most perfect accuracy.

The works of the ancients are often referred to as excelling, in magnitude, accuracy and beauty, those of modern times. This view is in part at least, quite erroneous. Their works were generally for useless purposes, although there are many exceptions, such as their canals, water works, military roads and bridges. The stones in the temple of Baalbec are the largest of any building in the world save one. They range from 1,200 to 1,275 tons. In one at St. Petersburg they are $\frac{1}{5}$ larger. The monoliths of Egypt are from 200 to 300 tons, and a few of 700 tons. The obelisk of Luxor, now in Paris, weighs 250 tons. The "goodly stones" of the temple at Jerusalem weighed 350 tons each. The probable method of constructing the great Pyramid of Gizeh, was by means a mound of earth and an inclined causeway; when the structure was completed the earth was removed. This

* It is estimated that there are over 40,000 locomotives in all countries.—*Ed.*

pyramid contained 6,500,000 tons of stone, and the embankments required 50,000,000 tons of earth. All of the masonry of the Erie Canal amounts to but one-third of this, and all of the earth moved for the Pacific Railway amounts to but that used instead of scaffolding for this pyramid. It required the labor of 500,000 men for thirty years, and cost $5,000,000,000. A modern engineer would construct such a work for $100,-000,000, and use a tithe of the men. The Coliseum at Rome was but one-third of the size of the London Exhibition building, and but one-sixth of the Paris building. The tonnage of the Ark was 12,000; of the show ships built by Ptolemy somewhat less, and of the Great Eastern 22,500 tons. Some of the modern men-of-war have nearly 9,000 tons displacement, and our passenger ships 3,000 to 5,000 tons. The largest steam engines in the world are those used in draining the Haerlem Mere, with steam cylinders of twelve feet diameter and fifteen feet stroke, driving eight pumps of 63 and 73 inches diameter, and ten feet stroke. These three engines were capable of delivering a volume of water six times as great as that of the Croton. The next largest pumps are those of the Graving Dock at Brooklyn, of one-third of the capacity of those at Haerlem Mere. The steam engines next in size are those of the Bristol and Providence steamers, with cylinders of nine feet two inches diameter and twelve feet stroke. Seven of the most noted modern engineering works to contrast with the seven wonders of the ancient world, are the Thames Tunnel, the Great Eastern steamship, the Atlantic Cable, the Britannia and Niagara bridges, the Erie Canal, modern ordnance, and the Pacific Railway.

Among the great projects of the age are those for building canals, railways, tunnels, bridges and steamers. In canals, we have the project of one around the Falls of Niagara; a re-enlargement of the Erie for vessels of 1,000 tons; the Suez, nearly completed; one across the Alleghanies in Virginia; one through the Nicaragua Lake or Panama, and one from Huron to Ontario. In railways, we have the Pacific on the eve of completion; the Mont Cenis in rapid progress; one across the continent from Rio Janeiro begun, and many others of magnitude. Of bridges, we have those in progress across our great Western rivers; one proposed across the East River at New York of 1,600 feet clear span; two over the Hudson, above and below West Point; another across the Straits of Messina, covering the "Scylla and Charybdis with clear spans of 1,000 meters (two-thirds of a mile) each," and with piers of 700 feet high, half in and half out of the sea, and finally the modern "Pons Asinorum," a bridge project across the Straits of Dover, sixteen miles long, in clear spans of two miles each, with piers of a 1,000 feet depth in the water. This project is said to be favored by Napoleon. In tunnels we have that of Mont Cenis, eight miles, and of the Hoosac, five miles in length, both in rapid progress; one of wrought iron tubes at London, and another at Chicago, almost completed; tunnels proposed under the East and North Rivers at New York, under the Ganges at Calcutta, and under the Straits of Dover.

The New York and Brooklyn Bridge.—The Board of Consulting Engineers, consisting of Horatio Allen, W. J. McAlpine, J. Dutton Steele, Benjamin H. Latrobe, John Serrell, J. P. Kirkwood and J. W. Adams, have finished their conference, after having sat for three days, carefully examining the details of Mr. Roebling's plans. The result, says the "Times," is a full confirmation of them in their application to the proposed East River Bridge.

The span (1600 ft.) the Board considered entirely feasible. As to the piers; on the Brooklyn side there was a substratum of boulders which the current would not act upon or wash away; here a firm foundation would readily be obtained. But on the New York side the foundation would have to be laid upon a quicksand—substantially the same as that met with in excavating the Dry Dock, where not a stone was found in the whole excavation. It is however very hard, being a decomposed rock. The practical question was, will the scour of the river remove it and undermine the pier? A reference to old charts shows that the current has not encroached upon this shore. The pier might be carried down 107 ft. to solid rock, but the Board thought going deeper than the bed of the river, or say 70 ft., unnecessary. In case of future encroachments, a protection of rip-rap work could be put in. The sand will be loaded to 4 tons per square foot. Mr. McAlpine has found that this sand will safely sustain 10 lbs. per square foot. The masonry will be located on a mass of timber 165×100 ft.×20 ft. thick, bolted together so as not to allow settlement in detail. The durability of this timber, below the mud, is beyond question.

IRON AND STEEL NOTES.

Report of the American Iron and Steel Association.—The following abstract gives the more important features of this valuable report. It is published in full in the "Iron Age" of February 25.

The estimate of the production of pig iron for 1868, is 1,603,000 tons* as follows:

	Tons.
Anthracite	893,000
Raw coal and coke	340,000
Charcoal	370,000
Total	1,603,000

The product by States was as follows:

Anthracite.	
Pennsylvania	671,955
New York	160,681
Other States	60,364
Total	893,000
Raw Coal and Coke.	
Pennsylvania	194,000
Ohio	132,000
Other States	14,000
Total	340,000
Charcoal.	
New England	30,000
New York	27,400
Pennsylvania	59,600
Maryland	25,000
Ohio	86,000
Michigan	65,000
Other States	77,000
Total	370,000

The estimated value of the pig iron made in the United States last year, at the average price at the principal market for each kind of iron, was $,000,000.

The product of the forges and bloomeries in the country during the past two years was as follows:

	1867. Tons.	1868. Tons.
New England	8,462	7,500
New York	22,634	23,000
New Jersey	5,980	6,200
Pennsylvania	31,747	33,500
Other States	4,250	5,000
Total	73,073	75,200

Estimating the proportion of the above product for 1868, made direct from the ore, at one-half, or 37,600 tons, a proportion found by careful analyses for previous years to be correct, we find that the grand total production of iron from the one in 1868 was 1,640,600 tons.

The product of the rolling mills in 1868 is estimated at 1,105,000 tons, an increase of 63,000 tons over the production of the previous year. This increase was chiefly due to the larger production of rails amounting last year to 506,714 tons against 462,108 tons in 1867.

Of the total domestic production of pig and rolled and hammered iron, as previously stated, the following are the quantity and value shown with reference to the various kinds of products:

* Tons in all cases 2,000 lbs., unless specially stated otherwise.

	Quantity. Tons of 2000 lbs.	Average value.
Foundry pig	575,000	$22,425,000
Rails	506,714	34,384,148
Boiler and plate	111,462	15,047,370
Nails and spikes	149,000	16,390,000
Bar, rod, band, hoop, &c., axles and other rolled irou	337,824	35,048,850
Hammered iron	22,000	3,960,000
Total	1,702,000	$127,255,368

The total productiou of steel in 1868, including 8,500 tons made by the Bessemer process, is estimated at 30,000 tons. The capacity of our steel works is amply sufficient for all the requirements of the country. The excellence of American steel, and its adaptability for every purpose to which this material is applied, can no longer be questioned. No reasonable argument, therefore, can be advanced against such additional protection as this interest demands, and which will redound to the advantage of the consumer no less than the producer.

The following are the quantities and values of the various kinds of iron and steel, and manufactures thereof, imported into the United States during the last fiscal year, comprising the twelve months ending June 30, 1868:

	Quantity. Tons of 2000 lbs.	Value.
Pig iron	118,042	$1,810,482
Castings	....	32,674
Bar iron	66,383	2,906,231
Boiler plate	1,000	73,221
Band, hoop and scroll iron	15,878	672,264
Railroad iron	228,277	4,781,575
Sheet iron	15,821	1,187,644
Old scrap iron	72,908	1,283,269
Anchors, cables and chains of all kinds	4,306	315,183
Steel ingots, bars, sheets and wire	....	1,705,337
Manufacturing of iron and steel	....	8,728,955
Total	522,615	$23,496,835

Later figures than the above, however, are obtained by a reference to the reports of the British Board of Trade, that for the eleven months ending November 30th, 1868, having recently come to hand. By it we observe that during that period 93,073 tons of pig iron were exported to this country, a falling off, as compared with the corresponding months of 1867, of 34,910 tons, and exhibiting a slight increase as compared with the importations of 1866. Of bar, angle, bolt and rod 43,388 tons were shipped hither, against 46,171 tons in 1867 and 68,376 tons in 1866.

One of the most prominent features of the iron trade during the past year was the very heavy importation of railroad iron, amounting during the period above named to 278,035 tons, being 101,820 tons, or about 58 per cent over those of 1867, and 169,603 tons, or 156 per cent over those of 1866.

Supposing the quantity shipped to this country in the month of December to equal the average monthly shipments of the previous eleven months, the total quantity for the year would be 303,000 tons, or nearly forty per cent of the whole consumption of the country—a quantity largely exceeding the importations of any year in the history of the country, excepting 1853-54. The total quantity of iron of all kinds exported to this country from Great Britain during the eleven months being 438,305 tons, against 391,526 tons in 1867, and 313,957 tons in 1866. Of steel we imported 16,700 tons, a quantity somewhat less than during either of the two preceding years. Of the whole quantity of iron exported from Great Britain during the eleven months ending November 30th, 1868, about 24 per cent was shipped to this country. The percentage of each kind sent hither was as follows: of pig iron, 16 per cent; of bar, angle, bolt and rod, 14 per cent; of railroad iron, 46 per cent; of castings 11¼ per cent; of hoops, sheets and boiler plates, about 12 per cent; other wrought iron, 3 per cent; of steel, 53 per cent.

The value of iron and steel and manufactures thereof, exported from the United States during the last fiscal year was $9,114,740, as follows:

	Manufactured in United States.		Of Foreign Manufacture re-exported.	
	Quan'ty (cwt.)	Value.	Quan'ty (cwt.)	Value.
Pig iron	7,331	$14,022	....	....
Castings	5,112	18,815	....	$1,035
Bar iron	3,580	22,515	746	1,755
Boiler plate	....	....	42	291
Band, hoop and scroll iron	....	....	20	97
Railroad iron	189	1,304	14,000	20,097
Sheet iron	....	....	501	2,022
Anchors, cables & cable chains	....	....	31	8,046
Nails and spikes	53,972	371,317	....	....
Manufactures of iron and steel	....	8,521,437	....	131,987
		$8,949,410		$165,330

THE ELLERSHAUSEN PATENT.—The specification of Francis Ellershausen, of Ellershause, and Augustus E. Stayner, of Halifax, Nova Scotia, and Adolph Guzman, of New York, N. Y., Letters Patent No. 84,053, dated Nov. 77, 1868, for "Improvement in the Manufacture of Iron and Steel," is as follows:

"The nature of our invention relates to the production of iron in a new and useful condition, suitable for the general purposes of the manufacture of iron and steel, and combining the advantages of improved quality and diminished cost. To enable others skilled in the art to make use of our invention in the manufacture of iron and steel, we will proceed to describe our method of operation, and the results attained thereby.

"Our process consists substantially in mixing together cast iron and an oxide or oxides in such manner and in such proportions as to produce a solid (as distinguished from a fluid) mass, one, and either, of them being in a solid condition, and the other of them in a fluid state, by reason of heat applied to it previously to such mixing. We shall, in this specification, describe more particularly our process as applied to the treatment ef melted cast iron with solid oxide. We use cast iron, either taken directly from the blast furnace, or remelted; and for the oxidizing agent, iron ore, crushed or pulverized, may be most conveniently employed, although we do not desire to restrict ourselves to the use of any particular oxide. The mixing may be effected in any suitable receptacle or mould, of such dimensions as will give to the resultant mass the desired shape and size. An ingot mould in two pieces, united and held together by bands, will answer the purpose.

"In the bottom of this mould we first place a small quantity of iron ore, so that the mixing may commence as soon as the melted cast iron is introduced. We then pour into the mould a stream of liquid cast iron, and, simultaneously therewith, a stream of finely-crushed or powdered ore, keeping the flow of each as steady as possible, and stirring them constantly with a tool (preferably made of wood), so as to effect an intimate admixture. Care must be taken that there shall be fully enough ore for the operation. It will be found that on this admixture the liquid cast iron instantly becomes pasty, and then solid, so that as the materials are poured in and mingled, a solid (as distinguished from a fluid) mass is built up until the mould is full. Removing the full mould, and supplying a fresh one continuously, the operation is kept up until the whole of the cast iron has been operated on. On opening these moulds, by removing the rings and wedges by which the sections are held together, the mass formed therein is turned out. This mass is a loose, spongy ingot, from which the excess of ore which has not combined with the cast iron will shake out.

"To the material thus formed we have given the name of "pig bloom," if cast in a mould or other such receptacle, and preserved in the shape thus acquired; but if the ingot be broken up small, or if this material be formed in such a manner as to consist of smaller pieces, flakes, granules, plates or scraps, then we call it "pig scrap." This "pig bloom," and "pig scrap," will be found to be mechanical mixtures or conglomerates, consisting of particles or grains of cast iron, of ore, of perfectly converted wrought iron, and of still other particles in various intermediate conditions. But if there have been tolerable skill and care exercised in mixing, the mass will be converted into a condition so nearly akin to that of wrought iron that it will only need the judicious application of heat to resume and complete the chemical operations, which having been commenced in the process of mixing, were arrested by the cooling of the mass, in order to perfect the conversion of the cast iron and the ore into wrought iron, by the combination of the carbon of the carburet with the oxygen of the oxide. In fact, this part of the after treatment is conducted as if the result of the mixing of the ore with the cast iron were already pure wrought iron, because the heating which is given to it during the further working, will supply all the conditions required for actually producing wrought or malleable iron. It will also be found, in practice, that this "pig bloom" and "pig scrap" are capable of enduring, without damage, a very great exposure to heat, both in intensity and duration, and thus the impurities can be sweated out of the metal to an extent which is not possible by the old methods of iron metallurgy, or at least not without great expense.

"The making of the pig bloom, or pig scrap, in the manner described, affords a convenient and very efficient means of obtaining the good effects of such materials as are known to be beneficial, either as detergents or as alloys, in some of the operations of iron metallurgy (as in the crucible), but which have wholly or partially failed to assist in the blast furnace, the refinery, the bloomery, the puddling furnace, or the Bessemer converter. By combining such materials with the pulverized ore, they enter into intimate mechanical admixture with the mass of the pig bloom or pig scrap during the process of "mixing," before described, and being thus imprisoned in the mass, and subjected for a long time to a heat too great for them to endure as solids, they must either escape as fluids or gases, or else become chemically incorporated with the iron.

"Instead of "mixing" by pouring the streams of finely-crushed ore and of fluid cast iron simultaneously into a mould, the same result, substantially, may be reached by scattering the cast iron on the bed of ore, or by delivering it on a moving surface, upon which ore may be placed before or after the metal is deposited; or, indeed, a variety of methods may be devised whereby to bring the fluid cast iron and the solid ore into a contact sufficiently intimate to produce a conglomerate of the character hereinbefore described. The method of operation may also be varied by employing the oxide or oxides in a melted state, and the cast iron, granulated or otherwise finely divided, in a solid as distinguished from a fluid state, mixing them in such manner as to produce the conglomerate desired.

"Iron ore or oxide of iron, has been described as the oxidizing agent in our process, but we do not confine our invention to the use of that material, as other oxides may be used in combination with or in lieu of it. We are aware that the removing of the carbon of cast iron to a greater or less degree, by means of oxides, is not new, and that the mixture of solid oxides with fluid cast iron is performed in the puddling furnace, and in other operations ; but this is done under other conditions, and with different results. But the novelty of our process consists in mixing solid oxides into and among fluid cast iron, or of fluid oxides with solid cast iron, granulated or minutely subdivided, in such a manner and in such quantity as to produce a solid conglomerate of the two substances, and also in effecting this mixture, and producing the resulting pig bloom or pig scrap, without the application of other heat than that of the fused cast iron or oxide, as the case may be, thus dispensing with the use of a furnace for any part of the process of mixing after the melting of the cast iron or oxide, whichever of them is used in a fused condition.

"It will be found that the material thus produced may be used in like manner as any wrought-iron of similar shape, so that when raised to a welding heat, the pig bloom, manufactured as hereinbefore described, may be pressed, squeezed, hammered, rolled, or worked in any of the methods employed in the treatment of wrought iron, and with like results, excepting that the article of wrought iron produced by our process is superior in quality to that obtained in the ordinary way.

"What we claim as our invention, and desire to secure by Letters Patent, is—

"1. As a new article of manufacture, pig bloom, or pig scrap, being a conglomerate of cast iron, oxides, wrought iron, and particles of matter more or less nearly approaching one or other of those substances, produced by admixing, and bringing in contact with fluid cast iron, oxidizing substances in a solid state, in such a manner and in such quantity as to produce a solid condition of the mass.

"2. The mixing of cast iron with an oxidizing agent, one or other of which is rendered fluid by heat applied previously to such mixing.

"3. The production of wrought iron from cast iron, by mixing with the latter, while fluid, a sufficient amount of oxidizing material to produce a solid condition of the mass.

"4. The production of wrought iron from oxides of iron, by mixing the latter with molten cast iron to such an extent as to produce a solid conglomerate of the two.

"5. The employment of detersive agents and useful alloys, by mingling them, or either of them, with the oxides used in the process hereinbefore described, so that they shall become part of the conglomerate, and have such intimate contact and connection with the mass as to produce their proper chemical effects when it is afterwards subjected to the action of heat.

WELDING POWER.—A powder of the following composition, recently patented in Belgium, is said to be very useful for welding iron and steel together. It consists of one thousand parts of iron filings, five hundred parts of borax, fifty parts of balsam of copaiva or other resinous oil, with 75 parts of sal-ammoniac. These ingredients are well mixed together, heated and pulverized. The process of welding is much the same as usual. The surfaces to be welded are powdered with the composition, and then brought to a cherry-red heat, at which the powder melts, when the portions to be united are taken from the fire and joined. If the pieces to be welded are too large to be both introduced at the same time into the forge, one can be first heated with the welding powder to a cherry-red heat, and the others afterwards to a white heat, after which the welding may be effected. Another composition for the same object consists of fifteen parts of borax, two parts of sal-ammoniac and two parts of cyanide of potassium.—These constituents are dissolved in water, and the water itself afterwards evaporated at a low temperature.

ANALYSIS OF BESSEMER STEEL AT THE DIFFERENT STAGES OF THE PROCESS.

	a.	*b.*	*c.*	*d.*	*e.*
Iron:					
Graphite	3.180	....	....	....	......
Combined carbon	.750	2.465	.909	.087	.234
Silicium......	1.960	.443	.112	.028	.033
Phosphorus...	.040	.040	.045	.045	.044
Sulphur	.018	trace.	trace.	trace.	trace.
Manganese ...	3.460	1.645	.429	.113	.139
Copper.......	.085	.091	.095	.120	.105
Iron	90.507	95.316	98.370	99.607	99.445
Slag:					
Silica	40.95	46.78	51.75	46.75	47.25
Alumina.......	8.70	4.65	2.98	2.80	3.45
Oxide of iron (Protoxide).	.60	6.78	5.50	16.86	15.43
Protoxide of manganese .	2.18	37.	37.90	32.23	31.89
Lime........	30.36	2.98	1.76	1.19	1.23
Magnesia.....	16.32	1.53	.45	.52	.61
Potash	.18	trace.	trace.	traces.	traces
Soda	.14	trace.	trace.	traces.	traces
Sulphur......	.34	.03	trace.	traces.	traces
Phosphorus...	.01	.04	.02	.01	.01

a. Gray pig (63 Austrian cwt. 83 pounds) and blast furnace slag.

b. After the first period ; slag from the converter.

c. After the second period ; slag from the converter.

d. At end on turning down ; slag from the converter.

e. Finished product after addition of recarbonizer; slag from converter.

First period ceases when long bright flame appears.

Second period ceases, as long bright flame begins to grow darker.—*Kupelwieser, Oest. Zeitschr.*, 1867, *No.* 23.

CHROMIUM IN RAIL HEADS.—The London "Mining Journal" states that an improved metal for the manufacture of rails has been proposed, consisting of iron with an admixture of chrome ore. It has long been known that an alloy of about 40 per cent of iron and 60 per cent of chromium scratches glass almost as deeply as the diamond ; and Fremy has stated that an alloy of iron and chromium may be formed by heating in a blast furnace oxide of chromium and metallic iron ; it resembles cast iron, and scratches the hardest bodies, even hardened steel. Experiments, says this authority, are now being made at four of the largest rail mills in the United States, in order to test the value of an alloy of chrome ore and manganese, with the iron in the puddling furnace, for hardening rail heads, and with every prospect of a successful result.

TREATMENT OF STEEL PLATES.—The tensile strength of a steel plate, with proper degree of hardness, should give an ultimate strength of 33 to 35 tons per square inch. The denser the metal the more injurious the effect of punching. Steel plates of from 33 to 35 tons per square inch tensile strength, suffer more by punching than iron plates of from 20 to 22 tons per square inch, unless the steel plates are annealed after being punched.

Effect of Annealing the Plates.—The plates which had been punched were annealed, when the tensile strength of plate arose to 35.86 tons per square inch or to its original strength. The mean results obtained of experiments of strength of drilled plates riveted together, and of punched plates annealed and riveted together—plates off of same piece—gave for drilled plates 41.075 tons per square inch, and for the punched 41.24 tons per square inch, showing the punched plate when annealed to be equal to the drilled, if the latter is properly annealed. Plates were 5-16 inch thick, rivets 9-16 inch diameter, 1⅜ center to center, and double riveted.

Mr. Henry Sharp found the effect of drilling and punching steel plates to be as follows:

Number of test.	Thickness.	Area.	Breaking weight on lever.	Weight per square inch of section when drilled.	Weight per square inch of section when punched.
			tons. cwt.		
1 D....	5-16	0.5437	19 3	35.22	....
1 P....	5-16	0.55625	14 17	....	26.690
2 D....	5-16	0.55	20 10	37.27	....
2 P....	5-16	0.5625	13 5½	....	23.735
3 D....	5-16	0.5466	19 18	36.40	....
3 P....	5-16	0.5593	12 12½	....	22.570

Thus proving that punching deteriorated the tensile strength of steel plates, 5-16 inch thick, to the extent of from 26.4 to 37.8 per cent, as compared with drilling, or on an average of 33 per cent. On examining a section of steel or iron plates which has been punched, it will be found that the metal is more or less hard and brittle around the hole (the thicker and harder the plate, the greater the distance).

Effect of Taper Punching on Steel Plates.—Plate ½ inch thick, cut in two, one piece, punched with a punch ⅞ inch diameter, clearance being 1-16 inch hole in die. The other plate was punched with the same punch, but clearance in hole being 3-16, making a taper hole in the plate. The ultimate tensile strength of plates, unannealed after being punched, was for the taper hole 32.527 tons per square inch of net sectional area; for the straight hole 26 tons, being 25 per cent in favor of the taper-punched hole, the fracture of the taper-punched plates being more fibrous than the other.—*Am. Railway Times.*

THE PRODUCTION OF PIG-IRON.—The estimated production of pig-iron in the principal iron making countries of the old world is as follows:—The figures refer to the year 1865, which is the latest date for which complete returns are obtainable. In the United Kingdom 613 furnaces made 4,768,000 tons; France, 430 furnaces, made 1,195,000 tons; United States, 260 furnaces, 1,150,000 tons; Belgium, 52 furnaces, 450,000 tons; Russia, 300,000 tons; Austria, 314,000 tons; Sweden and Norway, 253 furnaces, made 246,000 tons; Italy, 37,500 tons; Spain, 60,000 tons.

HISTORY OF SMELTING WITH RAW BITUMINOUS COAL.—Early in the seventeenth century, mineral coal was introduced as a substitute for charcoal in the manufacture of iron; but, the first experiments with raw coal being unsuccessful, the process of coking or charking was discovered, and for a considerable time held secret. It was still believed, however, that coking not only added expense, but wasted fuel, as modern experiments have abundantly proved; and attempts to use raw coal were not wanting. In 1651, a special act of Parliament granted to one Jeremy Buck a patent "for making iron with stone-coal, pit-coal or sea-coal, *without charking.*" Of the success of his operations we know nothing, but presume they resulted in failure; at least, so far as bituminous coal was concerned. A review of this part of the subject will be found in Webster's reports of English patent cases, under the head of the celebrated Crane case. Crane's patent (Sept., 1836) was for the use of raw stone-coal; and it was disputed on the grounds, among others, that he used bituminous coal also, and that the whole was covered by the ancient patents of Buck and others. This plea opened up an extended historical argument.

All these early experiments were made with cold blast, and they were not sufficiently successful to effect a discontinuance of the use of coke. Indeed, it became a maxim among iron-masters that raw coal decreased the product of iron. But after the year 1831, when the use of the hot blast was made more general, the introduction of raw pit-coal began in earnest.

The foregoing is from the "American Journal of Mining." A letter from Col. Chas. Whittlesey to the same journal says: The first use of raw bituminous coal in a stack furnace is claimed to have occurred in 1845, on the waters of the Shenango, in western Pennsylvania. A furnace built the same year on the Mahoning, another branch of the Beaver, just over the State line, in Ohio, made iron with raw coal; and immediately other works sprang up on both rivers, all using the "block," or Brier Hill coal, and all making an article superior to any coke or anthracite iron in America or England.

THE CELLULAR STRUCTURE OF IRON.—It is stated that a crystalline malleable iron does not show prisms is its fracture, but simply a number of faces of planes crossing the cells at right angles, cutting them off short. The process of rolling iron into plates or sheets does not obliterate these cells, but merely modifies them, as they widen out under the pressure; the thin partitions become laminated, and on the regularity of this lamination the quality of the plate very much depends. The cell system of copper is more perfect than that of iron, a result of the pouring of the copper into molds, but the cells are afterwards altered by the pressure in rolling, &c., but never destroyed. If it were possible to make a section one-millionth part of an inch in thickness these cells would be seen.

THE WILSON FURNACE.—The reported production of E. B. Wilson's puddling furnace is sixteen hundredweight of coal to the ton of puddled bars, running night and day. This shows a great saving over what has been used as a general thing in England, or wherever coal is cheap; but it is not so economical as a double puddling furnace built in the Cold Brook Iron Works, St. John, N. B., by Mr. John Wilson, an English furnace builder. This furnace made 42 tons ten hundredweight of six-inch bars (Scotch pig iron) with 27 tons of coal, half Cumberland and half Pictou, equal to twelve hundredweight and three-quarters to the ton of 2,240 pounds.—*Cor. Scientific American.*

ORDNANCE AND NAVAL NOTES.

Breech-loading Small Arms.—On this subject the "Engineer" says:

The great question of breech-loaders for military purposes seems to have reached its most important point, and already seems to lose a large share of interest accorded to it by the general public. The year 1867 was one of great change; last year was rather one of routine. The Small Arms Committee, at Woolwich, after having, early in the year, adjudicated the premium to Mr. Henry, set about their task of choosing a rifle for permanent use, either by availing themselves of the complete design of some candidate for Government remuneration, or by adapting the chief features of several into one perfect weapon. To perform their task efficiently they would necessarily have to institute a long course of experiments of great value in the aggregate, but of little general interest. Thus their time has been occupied for the year, and we believe we are correct in stating that in all probability their report will be published this month.

The report referred to has now been published. The "Army and Navy Gazette" thus comments upon it:

We understand that at length the report of the select committee on breech-loading firearms has been sent in, and it appears, as stated by us several weeks ago, the arm selected is a combination of the Martini action, modified by the committee themselves, and the Henry barrel. Without ourselves impugning this decision, we must, at the same time, say that, among very competent men, there is great doubt that such a combination will recommend itself either to military men, or those conversant with the adaptation of mechanical principles. We may briefly state a few of the objections to the Martini action. 1. A spiral spring has never been found to work with certainty in any arm yet tried. From its nature it is weakest when the blow is given to the cap; and the more the spring is expanded in the act of striking, the less its force, so that the impact partakes more of the nature of a sharp push than the actual blow necessary to ignite the fulminate in a cup. 2. There is always a certain amount of gas which combines the wax used as lubrication for the ball, and also round the cap itself. It is evident a portion of this is continually finding its way into the interior of the block through the opening in which the piston works, as well as at the slot, where the spiral spring acts on the trigger. This will necessarily tend to clog the spring and weaken its already uncertain action. 3. In intense cold—such as is found in Canada and other parts of the world, where the thermometer is frequently from 50 to 60 degrees below freezing point, and at other times from 90 degrees to 100 degrees above it—the condition of the steel in the spring would be so altered that it would be very liable to snap, and be rendered useless at the very time it might be required to act; and however easy it may appear to replace the spring in a workshop, it is not so in an exposed cold place, amidst falling snow, or in the face of an enemy. 4. The front part of the block is obliged to be made with convex face, and in consequence is tangent, and not parallel to the disc of the cartridge, therefore does not back it up as it should do. The result is that the arm is dangerous from the unsupported cartridges bursting, and the pieces of brass foil, of which the cartridge cases are made, being blown into the face of the soldier firing the arm. We understand that this has been endeavored to be overcome, by adding a spring to the block to force the face of it up to the cartridge, but this, it is held, would only add to the risk of clogging, and eventually render the arm useless until taken to pieces and cleaned by an armorer. 5. In loading the arm, should the trigger by any chance be caught in the dress or accoutrements of the soldier, it would not act. When the block closed the arm would, in all probability, be fired, as the whole force of the spring would be in the cap instead of being held back. 6. The breech-block works on a small pin, and, should this pin be too soft, it would soon wear loose and render the block still more dangerous, by causing it not to support the disc of the cartridge even at the point already named. If too hard, it would be liable to snap under the influences of the weather; the blows given by the constant firing would also alter the nature of the iron, by causing it to return to its crystalline state. 7. Extracting the empty cartridge case is effected in this arm by giving a smart pull forward to the trigger-guard when opening the breech. If at any time the pull is not sharp enough, the cartridge case sticks half way, and cannot be got out of the chamber without using the ramrod, and, on the other hand, should the pull be too hard, the empty case is apt to be sent into the face of the soldier firing, or that of his rear rank man. 8. The stock of this rifle is in two parts, which must weaken and unfit it for the rough usage of actual service. On the whole, we are assured that this arm is no improvement on the Peabody rifle, which has already been rejected. Nay, inasmuch as it has the manifest disadvantages of the spiral spring action, the latter weapon is held to be superior, and it is maintained that a rifle, on a bolt principle, will be found, for a military weapon, more safe, simple and effective, conclusions which have been arrived at by two of the greatest and most scientific nations on the continent—France and Prussia. There can be no doubt that the Henry barrel is a most accurate one, but whether it is well adapted for the rough usage of a military arm is a moot point.

In Prussia, says the "Journal Official," the results of a comparative trial which took place in the School of Musketry, at Spandau, amongst the breech-loaders adopted by the different armies, were, according to the official report, the following: The Prussian needle gun can fire 12 shots a minute, the Chassepot 11, the Snider 10, the Remington (Denmark) 14, the Peabody (Switzerland) 13, the Wœnzi (Austria) 10, the Werndi (same State) 12, and the Winchester repeating rifle (United States) 19.

In France the failure of the Chassepot and needle guns is announced. A correspondent of the "Army and Navy Gazette" says: The French and the Prussian Governments, after repeated experiments, carried on at a great cost, have arrived at this conclusion, and admit the fact—that the Chassepot and the needle gun (both on the spiral-spring principle) are useless for the central-fire cartridges, which they have now determined to adopt. Another authority informs us that the French Government have ceased to manufacture the Chassepot, and taken to the Remington instead. The Remington—the only rifle, by the way, which Prussian military men think superior to the Zündnadel—has been likewise introduced into the Danish and Swedish services.

American Rifles Abroad.—During the past year, Messrs. Remington & Sons, of Ilion, N. Y., have made 86,000 of the "Remington" breech-loaders of various styles, to fill foreign orders, and are now engaged in the manufacture of 40,000 "Berdan" breech-blocks for a Spanish contractor, to be used for the conversion of old muzzle-loaders, or to be applied to new guns, in Spain. We learn by a letter from Paris, written by one who ought to know, that orders are expected shortly from various European governments for about a million and a half of breech-loaders, and five hundred millions of cartridges. The greater portion of these orders will doubtless come to this country, and Messrs. Remington will undoubtedly receive a large share.

War Rockets.—At a recent meeting of the Manchester Literary and Philosophical Society, a paper was read on war rockets by Mr. J. Nasmyth, C. E. Mr. Nasmyth observed: It may be well to allude to the means that have been employed in the endeavor to secure to war rockets rifle action or precision of flight. These consist in placing the rocket in a V-shaped trough, by which the direction and inclination of the rocket is suitably secured previous to commencing its flight, and so far holding the rocket fair in the direction of the object aimed at. Besides this, an endeavor is made to give the rocket axial rotation during its flight by causing the propulsive gases, while issuing at the rear of the rocket, to rush through skew holes. This latter arrangement does, to a certain extent, give to the rocket axial rotation. But, as axial rotation given by such means does not come into effective operation until the rocket has proceeded a long way on its course, it comes into action too late to have any influence in securing precision of flight. In order, then, to effect our object, I place the rocket inside a tube, into which it slides freely; to this tube, which serves to secure the aim of the rocket, I give, by mechanical means, an axial rotation of some thousands of revolutions per minute, which is transmitted to the rocket then resting within it. The rocket, while thus revolving on its axis at the high velocity above named, is then fired, and so rushes forth from its guide tube impressed with all the conditions of a perfect rifle projectile, and, as such, with every condition present that can secure its reaching the object aimed at. The mechanical means and arrangements by which I propose to effect the object in question consist of a suitable iron stand, supporting the rocket and its guide tube, the latter resting on loose friction wheels, which, while preserving with the utmost exactness the direction of the axis of the guide tube and rocket, permits the guide tube and rocket to revolve on its axis with all due facility. The requisite amount of axial rotation is conveyed to the guide tube, and thence to the rocket resting within it, by means of a powerful clock spring transmitting its rotation to the rocket through a train of wheels. Previous to firing the rocket the second of this train of wheels is locked by a catch or trigger; the string is then wound up, and the aim and elevation of the rocket adjusted. The match of the rocket is then lighted, and in order to secure energetic combustion of the rocket ere it is allowed to rush forth on its course, the rocket is held in check by three slight springs within the guide tube at the rear of the rocket, by means of which it is not permitted to rush forth until the proper energy of discharge of propulsive gases has been acquired. As soon as this is the case the rocket frees itself and then rushes forth impressed with and possessing every condition of a true rifle projectile, combined with all those important properties which rockets possess as implements of war.

Failure of Large Breech-Loading Cannon.*—Says the "Army and Navy Gazette": There are serious rumors abroad respecting the new marine artillery. Somewhat more than a year ago France arrived at a different conclusion to that of most other nations, and "went in" for large breechloaders, with which she immediately armed her fleet. The breech would be difficult of description; suffice it to say that it is unlocked and removed on a movable platform. In a great many instances this apparatus has broken down during practice, and several guns have been altogether condemned. The strain of heavy charges has proved too severe a test on the mechanism, which gets out of order, and renders the piece difficult to be loaded or entirely useless.

* See "Ordnance and Armor," pages 580 and 608, for description of these guns, and predicted failure of large breechloaders.

As to the Armstrong guns, the "Army and Navy Journal" says: The English War Department, after spending millions of money on the Armstrong breechloading-wrought-iron-coil-rifled gun, knighting its inventor, and growing almost wild over their toy, have now finally abandoned the last vestige of the Armstrong system. It may, therefore, be stowed away among the relics of the past. Some patriotic loyal Americans, it will be remembered, took the Armstrong infection, and subscribed a handsome sum of money to present a battery of these guns to us, in the early part of the war. They seemed to be grieved that we had to trust to our simple smoothbore muzzle-loaders, when such a triumph of artillery-making was in existence. And some of our (present) English friends and admirals subscribed even more liberally to furnish the rebels with a lot of these guns, and others got into the Southern forts in various ways, so that they used to turn up every now and then when we took a Confederate stronghold. And yet, alas! their course is even now run! The British War Office has issued an order, intimating its purpose to withdraw all the breech-loading rifled guns and substitute muzzle-loaders. We learn from "Engineering" that the Ordnance Select Committee, at the request of the superintendent of the Royal Gun Factories, had been called upon by the War Department to decide on the peculiar construction upon which the 12-pounder, 9-pounder and 7-pounder rifled muzzle-loading guns, estimated for 1868–'69, are to be manufactured. They replied, subject to the Secretary of State for War's approval, that the 12-pounder and 9-pounder guns should be made in accordance with the tracings already approved to guide the manufacture of the experimental 12-pounder muzzle-loading gun, recently tried at Shoeburyness, with a view to the determination of the elements of rifling for these guns, as well as of the 12-pounder and 9-pounder experimental guns ordered for trial on board Her Majesty's ship Excellent.

European Iron-Clad Fleets.—The North German iron-clad fleet consists of five ships, viz: two cupola ships with 3 guns, two ships mounting 16 and one mounting 24 guns. All the guns are rifled breech-loaders of Prussian construction. Four of the ships are of iron. The King William, the largest of the five, has a tonnage of 5,939 and engines of 1,150 nominal horse power. The thickness of the plates used for these vessels varies from 4½ to 8 inches.

"Les Luttes de l'Autriche en 1866," lately published, states that the Austrian sea-going iron-clad fleet consists of two frigates of the first class, three of the second, and two of the third. They carry an aggregate of 213 guns and 2,592 men. There is also an iron-clad battery of position, with an armament of sixteen guns and a crew of 229 men. The same publication gives the strength of the Italian iron-clad fleet at four frigates of 36 guns, four of 26, and three of 22 guns each, one ram with 2 guns, two corvettes of 20 guns, two sloops of 4 guns, and two batteries of 12 guns each—in all eighteen vessels, with an armament of 388 guns and an equipment of 7,358 men.

Krupp's 11-inch Gun.—The 11-inch steel gun made by Krupp for the Russian Government, is the largest breech-loader that has ever stood a practical test. The gun weighs 26 tons, and has no preponderance. The rifling is 36 grooves of 770 and 788 in. pitch, 0.135 in. deep, and 0.64 (muzzle) to 0.79 (chamber) wide. The projectile weighs 495 lb.; the charge 82½ lb., giving an initial velocity of 1,360 ft. per second. The number of test rounds was 400, with substantially the above charges. The Prussian and the Belgian Governments have lately ordered a large number of Krupp's 9-inch guns.

THE GOVERNMENT AND INVENTORS.—The following circular, issued by the British Government, will be specially interesting in view of the current investigations, reports and general excitement on the subject among inventors interested in improving war material:

"In consequence of the numerous claims for compensation for loss of time and for expenses incurred by private individuals in working out inventions of various kinds, as well as for rewards in consequence of such inventions, the Secretary of State considers it necessary to make known the following regulations:

"1. Persons who desire to submit any invention for consideration should do so by letter, addressed to the Under Secretary of State. The letter should describe the invention, and state whether the person who offers it for consideration desires to make any claim to remuneration in connection with it. In the absence of such a statement it will be assumed that no such remuneration is expected.

"2. Expenses incurred before the submission of an invention will not be considered to give a claim for repayment. No liability on behalf of the public will be recognized on account of loss of time, or expenses incurred in connection with an invention after such submission, unless authority for such expenses has been previously given by letter signed by one of the Under Secretaries of State; and the liability will be strictly confined to the limits of expenditure authorized in such letter.

"3. All claims for reward will be examined by a council to be held at the War Office, and if any reward be recommended by the council and approved by the Secretary of State, the sum will, with the concurrence of the Treasury, be included in the estimates, together with the report of the council; but it will not be regarded as due or be paid to the claimant until after the vote is passed by the House of Commons.

"4. No claim for reward will be held to be established unless the invention has been adopted into the service or substantial benefit to the public has resulted from it."

THE ARMIES OF EUROPE.—The following statement of the nominal strength of the armies of Continental Europe was not long since given by Baron Kuhn, in the Austro-Hungarian Parliament:

France.	
Army	800,000
Mobile National Guard....	550,000
Total.....	1,350,000

North German Bund.	
Standing army	843,394
Landwehr	185,552
Total.....	1,028,946

South Germany.	
Standing army	156,760
Landwehr	43,411
Total.....	200,171

North and South Germany together.	
Total.........	1,229,117

Austro-Hungarian Monarchy.	
Regular forces, inclu'g navy & reserves ..	800,000
Border troops .	53,000
Landwehr	200,000
Total.....	1,053,000

Russia.	
Field army, including army of the Caucasus.......	827,350
Local forces ..	410,427
Irregulars	229,223
Total.....	1,467,000

Italy.	
Army.........	348,461
Mobile National Guard, including Venetia	132,300
Total.....	480,461

THE MONCRIEFF SYSTEM.—We are glad to be able to announce that the Moncrieff contrivance for mounting heavy artillery has been definitively accepted by the Government. Hitherto, as our readers are aware, a $6\frac{1}{2}$-ton gun is the heaviest which has been mounted on this system; but if it is to be really useful, it will have to be employed with much heavier ordnance, and steps are to be taken at once to apply it to a 12-ton gun, as a step towards its further development. Captain Moncrieff has been treated with a prompt liberality. He is to receive, first, a sum of money sufficient to cover the cost of his models and his preliminary expenses. Secondly, he is to receive payment for the time that he has devoted exclusively to the public service (about two years, we believe), at the rate of £1,000 per annum, which rate of pay is to continue so long as Captain Moncrieff is engaged in rendering assistance in making and completing designs for the application of his system, and in superintending the construction of his carriages. Thirdly, he is to receive £15,000 as a reward for the invention, and for the use which may be made of it in Her Majesty's service, either afloat or ashore, in any modification or combination. Captain Moncrieff on his part is required to undertake to communicate fully and unreservedly all improvements which he may deem practicable; in fact, to give the benefit of his knowledge of this particular subject to the country. Of the sum of £15,000, £10,000 is to be paid at once, the remaining £5,000 when the inventor ceases to draw his salary of £1,000 a year. These terms, we say, are liberal, and no doubt they will so be generally regarded; but they are not excessive.—*Engineering.*

THE PALMER SHELL.—A series of trials with a new shell, designed by Mr. Palmer, have recently been commenced at Shoeburyness. The shell is formed with a solid head and a base plate, the intermediate body being built up of a series of rings with serrated edge, which fit closely one upon the other, and together form a short cylinder; a through bolt, tapped at each end, passes through the solid head and the body of the shell, and is bolted to the base, holding the whole together. At the upper end, channels are cut in this bolt, to receive the fuze and communicate the fire to the bursting charge. The upper end of the through bolt is not flush with the point of the shell, but is recessed sufficiently to allow of the introduction of the fuze, which therefore abuts upon the top of the bolt, and cannot be driven into the shell at the moment of impact, as happens at present in the service shell. Two forms of shells were supplied by Mr. Palmer for the first trials at Shoeburyness, the one having a conical, the other a hemispherical head. The bursting charge was introduced through a hole in the bottom plate, which was afterwards closed with a gun-metal plug; the shells were fired from a 64-pounder rifled muzzle-loading gun, with the service charge of 8 lb.

TEN-INCH ARMOR PLATES.—The 10-inch rolled armor plates for protecting the four 22-ton 600-pounders which will be mounted in the two turrets of the iron-clad armored turret ship Monarch, 7,510 tons, 1,100 horse power, have arrived at Chatham dockyard from Sheffield. The plates are the largest ever yet operated upon at Chatham dockyard, each being 19 ft. in length, and weighing rather more than 12 tons. The process of bending the plates has been carried out by means of Westwood and Baillie's powerful hydraulic plate-bending machines, each plate having been bent to the arc of the circle it is to occupy on the turrets without giving signs of the slightest flaw. The plates will lose about two tons each while in the factory, the space occupied by the turret gun ports being cut from each.

RAILWAY NOTES.

Notes on Cheap Railways.—The following observations, by M. Desmousseaux de Gioré, C. E., on this important subject, from the "Correspondant," will be of interest to many of our readers at the present moment:

A railway is determined by two elements, which are, to a certain extent, independent of each other, namely, the weight of rails and the gauge: the weight of rails determines that of the engines; the gauge determines (according to the usual speed of traffic) the radius of the curves. On the principal lines of England and the Continent, the rails weigh about 36 kilogrammes per meter ($72\frac{1}{2}$ lb. per yard), and bear engines weighing 12 to 13 tons per axle; the gauge is about 1.50 meters (nearly 5 ft.), the radius of the curves being limited consequently to 500 meters (25 chains) on lines of rapid trafic, and to 300 meters (330 yards) on branch lines. The average cost of these lines is from 200,000 to 500,000 francs per kilometer, *i. e.*:

	Per kilometer.	Per mile.
For the great English lines,	545,000 fr.	£35,000
" French	305,686	19,647
" Belgian	230,000	15,000

In authorizing the construction of local interest lines, the French Administration has usually stipulated (at least as a condition of the State or department subsidy) that the great lines should have power to run their carriages over them; this clause has made the gauge of 1.50 m. compulsory, together with a minimum weight of rail of 18 kilos. per meter ($36\frac{1}{2}$ lb. per yard); but it soon became necessary to raise this weight to 25 kilos. ($50\frac{1}{2}$ lb. per yard) in order to adopt sufficiently powerful engines. The gauge being 1.50 m., it was necessary to limit the radius of curves to 300 meters, so as to avoid an excessive resistance. To such conditions, the cost per kilometer is usually between 100,000 and 110,000 francs (£6,440 per mile). It can be reduced, but not with safety, to 60,000 francs (£3,900 per mile). A frequent cause of excessive prices is the common prejudice against gradients, to reduce which expensive viaducts and works are incurred. But if engineers adopt steep gradients, and especially if they avoid joining the new lines with the old ones, they can reduce indefinitely the gauge and width of rails, and, consequently, the price per kilometer. For instance:

1. The railway from Breclthal (Prussia): gauge, 0.78 meters ($2\frac{1}{2}$ ft.); weight of rails, $10\frac{1}{2}$ kilos. per meter (21 lb. per yard); cost, 23,000 francs, including rolling stock; the radius of curves is 38 meters ($41\frac{1}{2}$ yards); the line is 20 kilometers ($12\frac{1}{2}$ miles) long; it occupies one side of the carriage road; the engines, loaded, and ready to start, 12 tons, with 6 wheels.

2. Railway of the sugar works (beetroot) at Tavaux-Pontséricourt, in the department of Aisne: two railways; gauge, 1 meter (3 ft. $3\frac{3}{8}$ in.); width of rail, 13 kilos. per meter ($26\frac{1}{4}$ lb. per yard); cost, 28,000 francs (£1,800 per mile), including all stock. Engines on four wheels weigh $7\frac{1}{2}$ tons, loaded; radius of curves, 30 and 40 meters (33 and 44 yards). The ground is very rugged; the section shows frequent gradients of 0.015 to 0.025, then long gradients of 0.050 and 0.060, and even one of 0.075; on a length of 300 meters (330 yards.) Messrs. Molinos and Prosnier, engineers of the line, and managers of the sugar works, might, but for the exceptional natural difficulties, have reduced the cost to 20,000 francs (£1,300 per mile). These lines are made on the side (*accotement*) of the vicinal roads. The legal formalities by which the necessary powers were obtained were very simple, the "communes" consenting to abandon to the company a strip of land of 1 meter in width on the side of the road, with power to add 1 meter to it. The two railways of Tavaux-Pontséricourt traverse two villages, without causing any inconvenience to the inhabitants. The legal formalities and construction were all completed for the greater part of the lines in six months.

The following cheap railways are described by Messrs. Flachat and Goschler, in their Exhibition reports:

3. Four Norwegian railways: gauge, 1.07 meters (3 ft. 6 in.); weight of rail, 20 to 22 kilos. (43 to 48 lb. per yard); weight of engines (four wheels) loaded, 17 tons; total length of lines, 300 kilometers (186 miles.)

4. Commentry and Monttucon line: gauge, 1 meter (3 ft. $3\frac{3}{8}$ in).

5. Antwerp and Gand line: gauge, 1.15 meters (3 ft. $9\frac{1}{4}$ in.). 16 trains run daily on this line at a speed of from 40 to 60 kilometers (25 to 36 miles per hour). In 1865, nearly 500,000 passengers were conveyed on it.

6. Mondalazac Railway, established by the Orleans Railway Company: gauge, 0.75 (2 ft. 5 in.); weight of rail, $16\frac{1}{2}$ kilos. per meter ($33\frac{1}{4}$ lb. per yard); radius of curves, 40 meters (44 yards); weight of engines (four wheels), loaded, 9 tons.

7. Festiniog Railway, near Caernarvon: gauge, 0.61; weight of rail, 15 kilos.; length, 21 kilometers; gradients, 0.0167; radius of curves, 40 meters; weight of engines, loaded, $7\frac{1}{2}$ tons; speed of trains, 16 kilometers per hour. From 1862 to 1863, this line was worked by horses. By using locomotive engines, the working expenses have been reduced 22 per cent.

This line is completely described in the "Engineer" journal.

8. Line built by Mr. Ramsbottom, C. E., at the Crewe Works of the North Western Railway: gauge, 0.46 meters (1 ft. 7 in.); radius of curves, 4 meters ($4\frac{1}{2}$ yards); speed of train, 10 kilometers ($6\frac{1}{4}$ miles per hour); weight of engines (4 wheels), $1\frac{1}{2}$ ton. A similar railway on the *accotement* of a road would certainly not cost 15,000 francs per kilometer (£1,000 per mile).

9. The Mont Cenis Railway, with central rail, invented formerly by M. Séguier, and re-invented by Mr. Fell: gauge, 1.10 meters ($3\frac{1}{2}$ ft.); gradients, 0.045.

Among the broad gauge* railways, the cheapest are:

1. In Scotland, according to a Swiss engineer, Mr. Bergeron, ten cheap railways, length from 10 to 30 kilometers (6 to 18 miles); cost, including rolling stock, from 73,000 to 145,000 francs (£4,700 to £9,400 per mile). Established ten years ago; others have probably been added since.

2. Vitré and Fougères Railway, 36 kilometers ($22\frac{1}{2}$ miles) in length; constructed by M. Debauge, at the rate of 67,500 francs (£4,400 per mile), including all stock. If the directors had not had the

* There is only one gauge in the original railway system of France, namely, 1.44 meters (5 ft. $8\frac{1}{2}$ in.). This is called broad as compared to those described above, but is very different from what we call the broad gauge.

unfortunate idea of connecting this line with the "Ouest," they could have reduced the expenditure to 56,000 francs (£3,600) per mile.

The above instances are sufficient to show the absurdity of constructing, as French companies are doing now, unproductive railways at a cost of 400,000 francs per kilometer (£26,750 per mile).—*Railway News.*

Extent of our Railways — Consumption of Rails.—The following statistics are from the late able and interesting report of Henry McAllister, Jr., Secretary of the American Iron and Steel Association:

	Miles.
The number of miles of railroad (including second track, sidings, &c.) in use December 31st, 1868	52,550
Total increase for 10 years ending December 31st, 1868	16,536
Total increase for last 5 years	9,448
Average annual increase for the last 10 years	1,654
Average number of miles in use for 10 years ending December 31st, 1868	43,123

	Tons.
Iron required in laying 43,123 miles averaged at 90 tons per mile, 3,781,070 tons, which at 6⅞ per cent for average annual wear, gives iron required for renewal of track	259,948
Iron required for last 10 years for renewing track	2,599,480
Iron required for last 10 years for new track, 16,536 miles, averaged at 96 tons per mile	1,587,456
Total consumption of railroad iron for last 10 years	4,186,936
Iron rails imported for 10 years ending June 30, 1868	1,015,685
Quantity of rails manufactured in the United States during the last 10 years	3,171,251
Average quantity of rails imported per annum for last 10 years	101,568
Average domestic production per annum for last 10 years	317,125
Total average annual consumption for last 10 years. (About 62 per cent of the consumption of rails is required for renewals and 38 per cent for new track)	318,693
Importation of rails for year ending June 30th, 1868	228,277
Production of American mills for year ending December 31st, 1868	506,714
Increase of importations on average of 10 years	126,709
Increase of domestic production on average of 10 years	189,589
Net increase of consumption in 1868, upon annual average of last 10 years	316,298

It seems to be the impression, particularly among those whose observations do not extend beyond our great trunk lines, that the percentage of rails worn out during each year is much greater than that given above, but this cannot be the case unless all the estimates that have been made of the number of miles of railroad in the country have been greatly exaggerated. It must be remembered that whilst many of the rails on main lines near our great railroad centers are worn out in a single year, there are thousands of miles of track in the Southern States and in the thinly settled portions of other sections that last over twenty years. In England, the actual waste of iron rails by grinding, oxidation and loss, is said to amount to 20,000 tons a year, while about 250,000 tons require to be taken up and re-rolled. As the number of miles of road there, including second track and sidings, may be safely put down at 23,000, it follows that the average wear and tear of track amounts to 10.36 per cent per annum. Even in that country, where the destruction of track is so much greater than here, we are told that on some lines of light traffic, rails frequently last twenty years, while on lines near London which are under constant and heavy work, many miles of track require re-laying in less than twelve months.

British Railway Accidents.—In the year 1867 the railway companies of the United Kingdom paid £347,379 as compensation for personal injury, 209 persons having been killed, and 795 persons injured; nineteen passengers were killed, and 689 injured from causes beyond their control, and seventeen were killed and eight injured through their own misconduct or want of caution. Fifteen servants of railway companies or of contractors were killed, and 62 injured from causes beyond their control, and 90 were killed and 28 injured through their own misconduct or want of caution; ten persons were killed and two injured at level crossings; 57 trespassers were killed (six were suicides), and five injured. In the six years 1862–67 the railway companies paid £1,460,568 as compensation for personal injury done upon the railroads. In those six years 1,268 persons were killed upon the railways, and 4,426 injured; and among them were 112 passengers killed and 3,897 injured without any fault of their own, and 97 passengers killed and 29 injured owing to their own misconduct or want of caution The risk of life in railway traveling may be expressed thus: In the year 1867 one in about eight and a half million passengers was killed—namely, one in every sixteen millions from causes beyond his control, and one in about every eighteen millions from his own misconduct or want of caution.

New Iron Railway Bridge in Italy.—MM Cail & Co. have contracted with the Upper Italy Railway Company for an iron girder bridge to be erected over the Po at Pontelagoscuro. The length of the bridge will be about 1,400 ft., with four spans of 247 ft. and two of 206 ft. It will be a single line, and supported by two lateral double lattice continuous girders, distant 15 ft. The piers and abutments will be sunk with iron caissons and compressed air. The weight of the superstructure will be 1,267 tons, and the price £24 per ton. Besides that, the price of each pier will be £4,720. There have been for this contract six competitors, all very large firms of France or Belgium.

Economy of Railway Transportation.—On a common road, wheat would consume its own value if carried 350 miles, while by rail it can be carried 3,000 miles at a profit. Railroads multiply by 10 the distance from any grain market at which its wheat may be raised. The same remarks apply to other productions, such as ores.

Railways in Canada.—After some years of inaction the minds of the Canadian people seem to be again undergoing agitation on the subject of railways. We have several times in this journal made reference to the proposed narrow-gauge lines, and it appears that the promoters of them are working energetically to accomplish their ends; it is sincerely to be hoped, however, that before they come to actual construction they will reconsider the whole matter and determine to adopt the gauge of the country. A Canadian correspondent writes to us concerning these lines as follows:

"One thing they are doing, however, which cannot fail to produce a healthy feeling in the public mind, and to convince people here that if they wish for railway accommodation, themselves must lead the way. The promoters of the narrow-gauge lines are thoroughly canvassing every municipality interested for aid by bonuses to their several projects, and they are meeting with a large measure of success. The principles they are endeavoring to instil into the minds of the people may be briefly stated as under: That the lines will be a vast and immediate service to the districts they pass through and will accommodate; that the country is too sparsely populated to warrant the assumption that they would pay in themselves as a commercial investment; that to insure the construction, at least one-third of their estimated cost should be a free gift from the municipalities; that they believe and hope one-third more can be raised in stock, and, if so, that no difficulty should be experienced in raising the remaining one-third, in the debenture bonds of the road. Whether they are right in the last impression or not, it is not for me to say, as they have issued no prospectus nor given the outside public any means of judging what their prospects of traffic are.

"The Port Whitby and Port Perry Railway scheme was chartered at the same time as the two narrow-gauge railway projects, but the directors of this line have wisely eschewed the error of departing from the established gauge of the country. This road will be about twenty miles in length, its southern terminus in Port Whitby on Lake Ontario, and its northern terminus in Port Perry on Lake Scugog; it lies wholly within the county of Ontario, and for its entire length will be of the utmost value as a thoroughfare for that important county, and will realize a considerable amount in local and thorough traffic. But the staple trade of the line will consist in its traffic in sawn lumber, Lake Scugog, with Port Perry at its head, forming a collecting depot for a vast chain of inland lakes and rivers, whose shores abound in pine timber of a very valuable description. It is estimated that this vast lumbering district will for a long series of years yield large supplies of timber for the American markets, while the lakes and rivers alluded to afford water conveyance of the cheapest character to the northern terminus of this railway, while the railway itself affords the shortest "portage" to Lake Ontario f om whence the lumber will be distributed to the various markets in the United States. Already the directors have had written contracts offered them for freight amounting to forty millions of feet, board measure, of sawn lumber annually; while in the prospect of the road being built numerous saw-mills are now being erected, depending on this railway as an outlet for their manufactures."—*Engineering.*

Cost of British Railways.—Ten years ago, the Brighton Company's system was 180 miles in length, and had cost eight and one-third millions, or £46,250 per mile. Since then the mileage has doubled, being now 365 miles, and the capital has more than doubled, standing now at about twenty millions. No less that five and a half millions of capital were raised between 1862 and 1866, and this without increasing the gross receipts by more than about 15 per cent. Yet as long ago as 1854, with but £7,690,000 of capital raised, the gross receipts were upwards of £685,000, whereas in 1866, with twice and half the capital, they had increased to but £1,190,000, or by but little more than one-half. The whole system of 365 miles has now cost nearly £55,000 per mile, on the average of the main line, extensions, and branches.

It will not be long after the meeting of Parliament, before it will be shown beyond disproof—although, of course, not beyond dispute—that a new main line can be made to Brighton at a total cost, including land (the latter alone taken at about £14,000 per mile), of only £35,000 per mile, and it can be as clearly shown that the first class fare between London and Brighton need not—and if an Act be obtained fixing the fare shall not—exceed 6*s.* for the 50 miles.—*Engineering.*

Business of the World's Railways.—According to the calculations made by the Government Statistical Office at Berlin, the number of passengers conveyed daily by the railways of the world amounts to three millions, and the quantity of goods to twenty-seven millions of centners, or a million and a half of tons. Also 58,000 telegrams are forwarded, and four millions of letters delivered every day. The daily gross receipts of the railways are 8,000,000 florins; they possess 40,000 locomotives, 1,200,000 carriages and vans, and give regular employment to a million persons. The aggregate length of the telegraph wires would, if united, reach to the moon and back again.

English Railway Carriages.—The long eight-wheel carriages of the Metropolitan railway weigh, with their gas apparatus, about sixteen tons, empty. The first class carriages seat 56 passengers; the third class, 80. A few four-wheel carriages are now being made of half the length and capacity, to weigh about seven tons each.—There will be a moderate saving of weight, but at the sacrifice, perhaps, of some degree of steadiness.

Belgian Railways.—In eight years the charges on goods on the Belgian State railways have been lowered on an average 28 per cent; the public have despatched 2,706,000 additional tons of goods, they have economized upwards of £800,000 on the cost of carriage, and yet the public treasury has realized £231,240 profit, after having paid the cost of working and the interest of additional capital.

A new Gauge.—It is proposed, among the schemes for improving London traffic, to make an open railway, with a three-feet gauge, from Islington to the Moorgate Street station of the Underground Railway.

Railways in Hindostan.—Four thousand miles of railway have been completed in Hindostan, and one thousand more are projected or commenced.

NEW BOOKS.

Description of Richards' Improved Steam Engine Indicator; with Directions for its Use. Second Edition Enlarged and Revised. By Charles T. Porter. London: Longmans, Green, Reader, and Dyer.

This is really a treatise on steam and the steam engine. "Engineering" reviews it in a long article from which we extract the following: Most engineers are familiar with a class of works which, whilst professing to be technical treatises or handbooks, are in reality nothing more than neatly worded advertisements or puffs of some particular machine or invention. To such books as these, that forming the subject of the present notice presents a remarkable contrast.

Mr. Porter has divided the second edition of his work into three parts, about half of the second part and nearly the whole of the third being entirely new. The first division comprises four sections, devoted respectively to an explanation of the nature and use of the indicator, to remarks on truth in the diagram, to a description of the Richards' indicator, and to directions for applying and taking care of the instrument. After explaining generally the action of the indicator and the object to be attained by its use, Mr. Porter enumerates the various sources of error which may operate to produce an incorrect diagram, and points out the means by which they may be avoided.

The second part of the book is divided into two sections, the first being devoted to directions for ascertaining from the diagrams the power exerted by the engine, and the second to instructions for calculating from the same data the amount of steam consumed. Both these matters are treated most comprehensively and clearly; and to this part are appended tables of the areas of circles; of hyperbolic logarithms; and of the properties of steam. These latter, which are very complete, have been prepared by Mr. Porter from the results of the experiments of M. Regnault, these results having been converted into English measures.

The third part of the work, which we consider to be even more important than those which precede it, is divided into five sections bearing the following headings: 1st, Observations on the several lines of the diagram; 2d. On the conversion of heat into work in the steam engine; 3d, The rotative force exerted upon the crank the same for all equal divisions of the diagram; 4th, The diagram not a true representation of the pressure on the crank; and, 5th, Of the motion of the piston as controlled by the crank through the medium of the connecting rod. The second section of the third part, that devoted to a consideration of the conversion of heat into work in the steam engine, is entirely new, and it forms, without exception, the clearest description of the mechanical theory of heat and of the action of steam during expansion that we have yet met with. Mr. Porter's remarks are illustrated by a series of examples carefully worked out, and the theoretical action of the steam deduced from these examples is compared with that which is shown by the indicator to take place in practice. In the next section, Mr. Porter shows that the rotative force exerted upon the crank being the same for all equal divisions of the diagram.

The fourth section of the third part, like the two which precede it, is quite new, and it treats on a subject of the greatest practical importance, namely, the influence exerted by the inertia of the moving parts in modifying the transmission of power from the piston to the crank at the different parts of the stroke. This is a matter to which Mr. Porter has devoted a great amount of attention, and the facts which he points out are worthy of being most carefully studied, particularly by those interested in the construction of high speed engines.

The last section of the book treats, as we have said, of the motion of the piston, as controlled by the crank, through the medium of the connecting rod, and it is accompanied by a most elaborate series of tables, showing, for different lengths of connecting rods, the motion of the piston corresponding to each degree of motion of the crank. These tables, which must have cost Mr. Porter an immense expenditure of time and trouble to calculate, give each result to seven places of decimals, and they are arranged in a novel manner. Each table is composed of four columns of figures disposed in concentric semicircles, the position of each particular result in these semicircles corresponding to the angle to which it relates.

Altogether the book is one which no engineer engaged in the construction of steam engines should be without; and least of all those of our profession—and they are now a numerous class—who are interested in what has been termed "high-speed engineering."

The History and Progress of the Electric Telegraph, &c. By Robert Sabine, C. E. London: Virtue & Co.

"Our language," says "Engineering," "is certainly becoming rich in the technical literature of telegraphy. For years it remained almost a barren waste. Mr. Culley first broke the spell, and the success of his work is shown by its having rapidly reached a third edition. Mr. Sabine succeeded, and latterly Mr. E. Bright and Mr. Latimer Clark have enriched the science with very valuable additions. The work before us is a second edition of the first portion of the larger work by Mr. Sabine that was published in 1867, and was reviewed by us in our number of February 15th of that year. Its price and size are both reduced. It forms part of Weale's admirable rudimentary series. Much has been added, some parts rewritten, and a good deal expunged. Altogether it is a considorable improvement upon the original, and it is a book which should be in the hands of every telegraphist, for it supplies a gap unfilled by Culley or Clark."

But the reviewer does not agree with the author as to the respective credit due to the fathers of telegraphy. What the reviewer says on this subject will be read in this country with, as the French say, an "uneasy interest." It is as follows:

"We do not wish to diminish one iota the credit due to Morse for the invention of the simplest, most perfect, and most universal telegraph in existence; but we protest against his being allowed priority of claim. We do not object to his immortality. If ideal conversations are to rank as inventions then should Galileo be called the inventor of the telegraph.

"Morse acknowledges having first received the conception of a telegraph in 1832; Wheatstone had been studying the subject years before this. Cooke and Wheatstone's telegraph was patented in the early part of 1837, and Morse's in the latter part of the same year. The first line of telegraph was erected by them in 1838, and the first line constructed in the United States was put in operation in the month of June, 1844. Cooke and Wheatstone's first 'hatchment' telegraph was a beautiful and practical instrument; Morse's first relays weighed 158 pounds, and required two men to carry them.

"We contend that the author's lights in meting out immortality have not been sufficiently luminous. We say Cooke and Wheatstone first, Morse a good second, Steinheil a bad third, and the rest nowhere."

Suggestions for the Sanitary Improvement of Laborers' Cottages and of Villages. By William Menzies, Deputy Surveyor of Windsor Forest and Parks. London: Longmans, 1869.

Practical Application of the Slide Valve and Link Motion to Stationary, Portable, Locomotive and Marine Engines; with New and Simple Methods for Proportioning the Parts. By Wm. S. Auchincloss, C. E., late U. S. Commissioner to the Paris Universal Exposition, and author of Report on Steam Engineering. 8vo. In cloth; 58 illustrations, with a valve travel scale. Price $2.50.

This work covers a field heretofore but partially occupied, and develops the fundamental principles of a subject over which, in many minds, hovers a cloud of doubt and uncertainty. Such a sense of vagueness is especially felt when one attempts to follow the intricate motions of a link, and to determine what effects different radii, as well as modes of suspension, must have on the character of the valve motion. It also sorely perplexes the student of steam engineering to discover some fixed principle by which he can at all times instantly determine for a simple slide valve and ports what dimensions will satisfy certain conditions, without following the tedious process of either substituting trial ones in several formula, and solving the same over and over again until, perchance, the right valves are reached, or of placing them on a model and noting their effects; or worse yet, by the geometrical construction of a number of ellipses. The first part of the work before us readily solves all such difficulties by means of an ingenious diagram called the "Travel Scale," from which the engineer can directly measure one after another of the desired dimensions with perfect confidence as to the result. Having explained the nature of the fixed single eccentric motion, illustrated with indicator diagrams the manner in which the action of its valve is affected by the angularity of the connecting rod, and furnished simple means for correcting the same, the author treats of the adjustable eccentric, which he makes introductory to the general subject of link motion. His method of investigating the latter is purely a process of geometrical construction. He entirely rejects the idea that algebraic or trigonometric formulæ are capable of here rendering any practical assistance. The plan of procedure is clearly defined and many means explained for varying the results. As the true radius of the link and position of the center of suspension are thereby determined with the greatest ease, the draughtsman can with its aid quickly scheme a satisfactory link motion without resorting to an expensive link model. The shifting, stationary, Allan and Walschaërt link motions are consecutively examined, and their points of similarity compared. The subjects of independent cut-off, clearance, friction, etc., have likewise received due consideration. To the draughtsman, master mechanic and student of steam engineering this little work will prove a most invaluable assistant, not only preventing the occurrence in designs of mortifying mistakes, but greatly economizing the time of execution.

Exposition Maritime Internationale du Havre. 1868. Rapports du Jury International. London: Johnson & Sons.

The rapidity and completeness with which the jury reports of the Havre Maritime Exhibition have been published presents a striking contrast to what we have hitherto been accustomed. It is compiled in two languages—English and French—and contains a complete list of awards as well as the reports of the juries. As to its accuracy we are not in a position to speak, but there can be no doubt of its excellence in a typographical point of view. Every care appears to have been taken to ensure correctness, the proofs having been submitted for final revision to the president and reporter of every class or section, they being held responsible for the accuracy of the awards and the motives assigned for them. The original intention of the promoters of the Exhibition was that it should follow immediately the "Universal" at Paris, and be supplementary to it. The docks at Havre enabled the jurors to establish a species of competitive examination of vessels afloat, and to test the improvements that had been made of late years by inspecting, not merely models on a large scale, but the ships themselves. With few exceptions, all foreign nations, England especially, co-operated by sending liberal contributions. A very novel feature in the Havre Exhibition was the election of the jurors for each class by the suffrage of the exhibitors, an arrangement which proved highly successful. The compilation of this work, containing nearly 600 closely printed pages, must have been a task of considerable difficulty and responsibility. The mode in which it has been accomplished is highly creditable to the publisher, to whom the undertaking was entrusted by the Commission of the Exhibition.—*Engineering.*

The Royal Engineer. By the Rt. Hon. Sir Francis B. Head, Bart. London: John Murray, 1869.

Sir Francis Head certainly deserves well of the Royal Engineers. He has visited Chatham, and has inspected the Mounted Engineer Train at Aldershot, and has committed the results of his investigation to print. It is well that somebody has done so, for otherwise the solid work which is done by the most scientific branch of the army might have passed unnoticed. We now know the composition and working of the photographic and electrical school at Chatham, as well as the whole means which are adopted at the Royal Engineer establishment to train the sappers and miners of the British army in photography, surveying, field works, and the construction of entrenchments. Sir Francis Head describes the Royal Engineer *ab ovo.* He relates how he is first admitted into the Royal Military Academy at Woolwich, educated there, and in a chrysalis state transmitted to Chatham, where he completes his practical and technical instruction. He even describes the various schools at the Engineer establishment, at which the non-commissioned officers and men are prepared for their several duties. Each different species of them requires a separate training and separate instruction. The draughtsmen, the surveyors, the photographers, the electricians, are all subjected to diverse treatments, which are clearly recounted in the book before us. Those who wish to find all that pertains to the preparation of both officers and men of the Engineers for their duties both in the field and at the desk, as well as any who are interested in the requirements for obtaining a commission in that corps, will derive much value from Sir Francis Head's work.—*The Engineer.*

A large, carefully prepared work on military engineering; octavo; 400 pages.

The Elements of Heat and of Non-metallic Chemistry. By Fred'k Guthrie, A.B.(Lond.), Ph. D., F. R. S. E. London: Van Voorst. 1868.

Mr. Guthrie evidently thinks that even elementary treatises like those of Balfour Stewart are of too difficult a character, and that works like that of Lardner are too general for the requirements of the London University. He has, therefore, attempted to compile a book which, while avoiding the mathematical details of higher treatises, should bring together, in clear and intelligible language, the leading phenomena and laws of heat and of non-metallic chemistry. His endeavors have been in some measure successful, and in some degree also have failed in their purpose. For instance, while he has treated the subject of heat in accordance with the aim he had in view, he has fallen short of his aim in dealing with the chemistry of the non-metallic elements.—*Popular Science Rev.*

MISCELLANEOUS.

MACHINE BUILDING IN EUROPE.—There are many and large—some of them very large—engineering establishments upon the Continent, and they appear to be busy, busier than works of the same class in England. Besides the large engine works of the French government at Indret, near the mouth of the Loire; and the large railway workshops of the six great French railway companies, there are, in Paris, the works of Cail and those of Gouin, employing at times, the first 2,000 and the second 1,000, or more, men. There is tho great establishment of Schneider & Co., at Creusot; the fine locomotive works (we have none better nor larger) at Fives, near Lille; the large works of André Koechlin & Co., at Mulhouse; the Graffenstadten works on the Rhine; and, as for marine engine-makers, besides those at Indret, and Schneider & Co's, the large works of Mazaline & Nillus at Havre, and those of the Mediterranean Company at Marseilles. The Creusot works alone employ between 9,000 and 10,000 workpeople in all departments, and few of the others named employ less than 1,000, and some of them very many more.

In Belgium there are the great Société John Cockerill, employing many thousands of hands, the Couillet Company, the Société St. Leonard, and others. In Holland there are the large iron ship-building and engineering works of Paul Von Vlissingen & Dudok Von Heel, at Amsterdam. In Switzerland are large works at Zurich, viz: those of Escher, Wyss & Co., of which Matthew Murray Jackson, an English engineer, is manager; and in Bavaria are the large bridge building works of Klett & Co., of Nuremburg, and the smaller engine works of Maffei, at Hirschau, near Munich. There are extensive engine works also at Carlsruhe, in Wurtemburg, and there are machine making establishments of various degrees of magnitude scattered over a large portion of the Continent.

Borsig, of Berlin, some time since turned out his 2,400th locomotive; he sent his 2,000th to the Paris Exhibition. Experts speak in high terms of the character of Borsig's workmanship, ranking it much above that of the French and Belgian engineers. He employs steel very largely, much of it of his own manfacture, and he gives a high degree of finish, not only to the working parts, but to some others which with us are painted. His contracts are largely upon Russian account. Borsig's large iron works at Moabit, four miles out of Berlin, have been converted into a great boiler factory, and his iron makers are being transferred, to the extent of one thousand families of workpeople, to a new establishment in Silesia.

Hartmann, of Chemnitz, in Saxony, now employs 1,800 men and boys, and is constructing machinery of almost every class. He has lately built an erecting shop, to receive thirty-five locomotives in a single row, and, allowing no more than sixteen feet from center to center of pits, this building must be upwards of 550 feet long. His make of engineers' tools, cotton and woolen machinery, turbines, &c., is very large.

PATENTS.—About 4,000 "provisional protections" are granted yearly at the British Great Seal Patent Office, the protections granted being within, perhaps, a dozen or so of all the applications made. Of these protections only about two-thirds pay the additional £20, which gives them the force of a patent. At the end of three years from the original grant the patent lapses unless £50 more be paid, and at the end of seven years from the grant £100 more must be paid to continue the patent for the full term of fourteen years. In the year ending September 30th last, 14,153 patents, re-issues and protections of designs were granted by the United States Patent Office. Over 20,000 were applied for.

THE INTRODUCTION OF STEAM FIRE ENGINES.—Steam power for extinguishing fires was in use in manufacturing establishments many years before it was employed on portable machines. Every factory of any pretensions had its steam-driven pump with hose and other attachments calculated to reach every portion of the establishment. About the year 1829 or 1830, Capt. Ericsson, then of the firm of Braithwaithe & Ericsson, London, England, built and exhibited a portable steam fire engine. In 1842 or 1843 he produced a similar engine in New York city, and it was tested but never brought into regular service. The writer remembers a great objection urged against its use, that it burst any hose that could be made, which showed that the fault of want of success did not lie with the machine.

So far as we are informed, the credit of overcoming prejudice and successfully introducing the steamer in cities and large towns belongs to Miles Greenwood, when mayor of Cincinnati, Ohio. Mr. Greenwood, being a man of great tenacity of purpose and a thorough mechanic, and having, moreover, the confidence of his fellow citizens, succeeded where only failure awaited others; and, in consequence, Cincinnati was the first city to adopt the steamer as a permanent portion of its fire department force.

The reasons why this most efficient agent—steam—was not sooner utilized for the protection of property from fires, may be summed up in one word, prejudice, prejudice born of ignorance. Fire and steam careering through the streets instead of inducing confidence and a feeling of security, inspired terror or created apprehension. Our municipal authorities, too, are not generally engineers or mechanics—and—the steamer does not vote.

The metropolitan fire department of New York city numbers 34 steamers of about 50 H. P. each, equal to 185 men, or, in the aggregate, 6,290 men, while the actual number of men employed, even adding the 12 hook and ladder companies, is only about 550: thus relieving 5,740 men from the labors, dangers, and the exposure of the fireman, and allowing them to become producers rather than merely protectors of property. The time is past to question either the superior efficiency or tho economic advantages of the steamer over the hand engine. As well might we return to the old hand press and the spinning wheel, print our newspaper editions of 100,000 daily and clothe the teeming millions by hand labor, as to discard the powerful agency of steam in the protection of our property from fires.—*Scientific American.*

NEW GALVANIC BATTERY.—A new battery is announced as arranged by M. P. Guyot, which may be useful for telegraphic purposes and electrical alarms. It consists of a porous earthen vessel filled with finely-powdered iron ore, in which is plunged a cylinder of gas retort charcoal and an ordinary vessel filled with concentrated solution of common salt, in which is placed a slip of zinc. The only care required to keep such a battery in order is to keep the latter vessel always full of concentrated solution.—Further, the solution may be replaced by sand impregnated with it or by salt in crystals, the humidity of the atmosphere being always sufficient to serve as a solvent. If the latter form be found to answer, the battery would be extremely convenient on shipboard, in trains, or wherever there is motion.

A MUCH NEEDED BOOK.—Our publishers have many inquiries for a work on the *American Steamboat Engine,* containing engravings (not necessarily costly) and details of valves and valve gear, and other parts and their working. A book is wanted that will teach a mechanic having some theoretical knowledge or a student having some practical ideas, how to set the valves and operate and maintain this kind of engine to the best advantage.

The American Master Mechanics' Association.—We take pleasure, says the "Western Railroad Gazette," in laying before our readers a few facts connected with the objects and operations of the American Railway Master Mechanics' Association, now approaching the third year of its existence. This association is composed of the master mechanics of the railways of the United States, whose object is that of improving the motive power of the several roads which they represent, and also determining the best and most practical as well as the most economical system of construction and management thereof. For this purpose committees are appointed among themselves to report upon the different subjects connected with their department of railway management. These reports and the attendant discussions are published for the benefit of the railways at large. We are confident that no mechanical association has been found comprising a greater degree of practical intelligence; and when it is borne in mind that this report will embody the combined experience of over two hundred of the ablest mechanics and engineers of our country, it will at once be understood how valuable a text book these reports will make. Mr. L. P. Dodge is the secretary of this committee, and is now making the tour of the United States, visiting each master mechanic, and, in per on, procuring data and information for the required reports. Perhaps the most important committee for the coming year is that upon "boilers," composed of Messrs. Hayes, Illinois Central Railway; Jauriet, Chicago, Burlington and Quincy Railway; and Anderson of the Chicago and Northwestern Railway; as it is to take up the question of *steel plates* as a substitute for iron or copper, and we are informed that thus far the experience of many of the largest roads is largely and unmistakably in favor of its use, especially in coal-burning locomotives. Their next meeting is to be held at Pittsburg in September, due notice of which will be given.

Bleaching of Wood-Pulp for Paper.—M. Orioli, a French chemist, says, in the "Revue Hebdomadaire de Chimie," that the chloride of lime, if the dose is the least in excess, has a tendency to give a yellow tinge to the pulp; that all energetic acids, without exception, tend to give a reddish color to the paper when exposed for a long time to the effects of the sun or of moisture, and that the least trace of iron is sufficient in a very short time to blacken the pulp. He says he has succeeded in avoiding all these inconveniences by the use of the following mixture: For a hundredweight of wood-pulp, he employs 400 grammes (four-fifths of a pound) of oxalic acid, which has the double advantage of bleaching the coloring matter already oxidized, and of neutralizing the alkaline principles which favor such oxidation; he adds to the oxalic acid one pound, or a little more, of sulphate of alumina, entirely deprived of iron.—The principal agent in this mode of bleaching is the oxalic acid, the power of which over vegetable coloring matters is well-known; the alum has no bleaching power of its own, but it forms with the coloring matter of the wood an almost colorless lake, which has the effect of increasing the brilliancy of the pulp.

The Effect of Cold on Tin.—It is stated in a recent number of the "Comptes Rendus," that according to Herr Fritsche, tin exposed at St. Petersburgh last winter to a temperature of 40° below zero was converted into a semi-crystalline mass containing cavities like basalt. In masses of tin weighing from 55 lb. to 66 lb. these cavities in some cases had a volume amounting to nearly 24 cubic inches.—According to M. Dumas facts of this kind are not new in Russia; for instance, in one case the pipes of a church organ were so altered by the cold as to be no longer sonorous.

New Horse Shoe Machine.—Some interest has been excited in Birmingham by a new machine for the manufacture of horse shoes, invented by M. Bastien, Paris. The principle of the invention is the hydraulic press. The process is as follows: Immediately the bar comes red hot from the furnace the iron is transferred to the rolling mill. Here a movable piece on which the bar is placed receives an alternative motion from two pistons of the hydraulic press. This movable piece presses the bar between two left-hand sliding surfaces, which impart to it a bend. It is next very strongly pressed on a die, thus receiving the definite form, while at the same time the nail holes are pierced, and by means of a spring the movable piece recedes and allows the finished shoe to fall out into a shallow tank of water placed underneath. The action of the machine suffices to make a shoe at each motion, forward and back, thus preventing any waste of power. The dies and stamps are easy of adjustment, and may be immediately exchanged for the production of larger and smaller shoes at discretion. Two pressures are necessary, namely, one of from four to five atmospheres to produce the form of the shoe, and another of from 100 to 150 atmospheres to pierce the nail holes. A movement of from six to eight strokes per minute can easily be obtained by this machine, producing as many shoes as strokes. The success which has attended the invention on the Continent is likely to be supplemented in this district by ironmasters at present engaged in the production of horse shoe bars.—*The Engineer.*

Value of European Patents.—The American origin of an invention is now a recommendation in Europe, where many of these inventions are in successful operation, and large fortunes have been realized by their introduction. Improvements relating to some manufactures are of great value in this kingdom. Mr. Bessemer derives an annual income of about $2,000,000 from his British steel patents, and the patentee of a device for dressing mill-stones, by a revolving diamond, has realized over $1,000,000 the first year of his patent. The use of a diamond for this purpose is an American invention, and the estimated value of the exclusive right in England, for ten years, is $5,000,000. British patents, as a rule, are the most valuable, but many inventions are equally profitable in other parts of Europe, and some are peculiarly adapted to continental wants and customs.—*Hazletine, Lake & Co's Circular.*

The California Big Trees.—Within a space of fifty acres, in the Original Grove, there were (in 1865), 103 trees of great size, twenty of which exceeded twenty-five feet in diameter at their base. The "big tree stump" had room enough for thirty-two persons to dance four sets of cotillions at the same time; besides many musicians and spectators. Across the solid wood of this stump, at 5¼ feet from the ground (*without* the bark, which equalled 15 to 18 inches in thickness), it measured 25 feet. This glorious tree was sound to its center, and was 302 feet in height and 96 feet in circumference at the ground. The "Father of the Forest," the *largest* tree of the entire group, measured in circumference, at the ground, 110 feet.

German Locomotive Prices.—Herr Borsig, of Berlin, has recently received an order from the Rhenish railway for twelve locomotive engines and tenders for working passenger or goods trains. The engines weigh, empty, thirty tons, sixteen cwt. and the tenders eleven tons, four cwt; the price of each engine and tender is £2,625.

The Heaviest Lathe.—The Lowell machine shop is now building the heaviest turning lathe in the country, to weigh seventy tons.

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PERMANENT WAY.

REPORT OF THE STATE ENGINEER OF NEW YORK. PREPARED BY S. H. SWEET, DEPUTY.

From the advance sheets of the Report of the State Engineer and Surveyor of New York, on Railroads.

The following timely, able and practical considerations form a part of the State Engineer and Surveyor's Report for 1868 upon Railroads. Official reports upon such subjects are often valuable in their details, but it is not often that a government engineer reads a sound, practical lesson to our railway managers and railmakers. Mr. Sweet obviously understands the mistakes that have been made and the ends that should be sought in both these departments, and he does not hesitate to characterize them in plain language. We copy, on this occasion, his remarks on Road-bed, Sleepers, Joints and Iron Rails. In a future number we shall quote the report on the subject of Steel and Steel-headed Rails.

Increasing Demand for Permanence of Way.—The statistics of European, as well as of American railways, clearly indicate that any notable economy of working and maintenance must be accomplished chiefly through the improvement of railway *tracks.* The renewal of rails is the largest item in the cost of maintaining a railway, and the modern system of running heavy trains by much heavier and longer engines, is throwing more work upon the rails every year. The increased *articulation* of locomotives, so as to relieve the lateral strains upon the road and the individual weights upon the wheels, though promising well, is yet experimental. When fully worked out, it will also lead to a still greater loading of trains, for in the other departments of working a railway, economy lies in the greatest possible concentration of power, attendance and labor. So that, however running gear and steam machinery may be improved, the permanent way of trunk lines, at least, always will be, and probably should be, worked to its full capacity. In fact, the strength and durability of a given track is the feature that limits the amount, and hence the economy of the transportation that can be done upon it.

But there is another and more formidable destroyer of permanent way than weight, and that is speed. The running time of our passenger traffic, instead of being shortened as the distances to be reached were increased, has been lengthened, as compared with the speed of ten or fifteen years ago. Whatever risks and expenses rival lines may have adopted in other particulars, they have harmoniously abstained from running fast trains. *This* is a bid for patronage, which the most reckless manager has not dared to make. The public have tolerated this state of things longer than could have been expected. There is now a general and growing demand for fast trains. The time of one individual is worth more than it was when railways were introduced, and thousands of individuals travel now where dozens traveled then. In view of the opening of the Pacific railway, the development of the vast and growing States of the far west, and the steady tide of business and pleasure travel from these distant regions to our seaboard, the economy of fast trains is to be counted by days instead of minutes. To meet this requirement, the first and heaviest demand must be made upon the permanent way. The steam engine and the vehicle may be adapted to high speed with comparative ease and economy, but every rail, every joint and every sleeper, from the Atlantic to the Pacific, and between all the centers of population, must be maintained in a condition not only to bear fast trains safely and smoothly, but to endure the quadrupled strains and percussions due to a doubled speed.

Every increment of "work done" upon a railway, every increase in the weight, number or speed of the wheels, every economy of concentrating labor and power, brings an increased demand for endurance directly upon the permanent way. And, indirectly, the quality of the permanent way determines the economy of power of traction and of maintenance of engines and rolling stock.

In the construction, of new lines, a vast economy in earthworks and viaducts may be obtained by means of heavier grades and curves, but at the expense of increased wear and tear of permanent way.

The desirableness, if not the necessity, of increasing the durability of our railway tracks, even to meet present demands, is the truth of all others that our railway managers do not require to be told. The object of the foregoing remarks is to remind them that this necessity, instead of decreasing, must constantly and rapidly increase, as traffic grows and railways reach out into the wilderness.

Drainage, Ballast, Etc.—The improvement of the road-bed, by means of better drainage and ballasting, although of very great importance, presents no engineering difficulties. The practice and the economy are well settled, and it is simply a question of spending a shilling to save a pound.

Sleepers.—The preservation of sleepers by chemical processes, is always the subject of experiment on one or another of our railways. The practice, however, is not general in this country, because the mashing of the rail into the sleeper usually destroys it in advance of decay. In England, the bearings of the chairs used (with the double-headed rail) on every sleeper, are so extended, that the mechanical injury of the wood is quite small; prevention against decay—usually immersion in coal tar—is therefore generally practised. The insufficient bearing offered by sleepers to the rails, is thus, directly and indirectly, the cause of their rapid destruction. It is stated that placing the sleepers closer than, say two feet apart centers, would prevent the convenient tamping of the ballast. It is objected to the longitudinal sleeper, that the rail, lying parallel with the fiber of the wood, mashes into it more easily than into the cross sleeper. These objections to sufficient bearing, are not inherent in either system, but arise from improper construction. Thoroughly good ballast would not require continual tamping. It is even proposed by some of our most experienced engineers, to cover the ballast with a coating of coal tar and gravel, to absolutely exclude water, and thus to prevent not only decay, but washing, freezing, heaving, settling—all destroying elements but vibration and wear. In this case, the timber bearings under the rails should be almost continuous, to prevent wear both on the ballast and on the rail. The mashing of rails into timbers, either longitudinals or cross sleepers, is largely due to the want of stiffness in the rails themselves. The low ∩ rails on the Great Western of England, are the most notable examples of this kind of failure. If the iron wasted in the thick stem and pear head of our worst shaped rails, were put into the *height* of stem, their resistance to deflection would be doubled, this resistance being as the cube of the depth.

There is a growing conviction among engineers, that the longitudinal system will become standard. It offers twice to three times as much bearing for the rail as the cross sleeper system. The whole strength of a longitudinal is added to the strength of the rail, considered as a beam to carry the load. The strength of the cross sleeper in this direction is wholly wasted. The longitudinal is almost certain to prevent the displacement of a broken rail. This system has never been tried on a large scale, with a high, stiff rail. It requires better ballast and more thorough adjustment than the other system. Independent points of support, like the isolated ends of cross sleepers, that can be blocked up or let down at pleasure, without reference to the rest of the superstruction, are the indispensable accompaniment of bad ballasting and imperfect drainage. But they are unsuited to any system of homogeneous, continuous and *permanent* way.

Iron sleepers are coming into use in countries where timber is very costly and unsuitable, and are the subjects of various experiments in England. The great defect of all imperishable sleepers, whether stone or iron, has been want of elasticity. An anvil under a rail, and especially under a joint, is almost worse than an insufficient support. The failure of stone blocks on the Lowell, Camden & Amboy and various English lines, is often quoted to prove that rails cannot be laid on a stable and durable foundation. This is a most serious mistake. An inch thickness of wood between a driving-wheel rim and a tyre, doubles the endurance of a wheel; a quarter of an inch of rubber confined in a suitable chair allows the laying of rails upon stone blocks, without extraordinary wear. A great range of elasticity, or a general giving-way of the road-bed are not required—only an imperceptible yielding to the minute, but incessant vibrations known as jarring, which would otherwise destroy the whole fabric. A pocket cut in a stone block or cast in an iron sleeper and filled with a cushion of wood or rubber would afford all the elasticity required.

Rail Joints.—The selection of joint fastenings for the ends of rails is somewhat dependent upon the weight of rail required and hence upon the traffic. After twenty years of competitive trial with every variety of fastening, the simple fish-joint—an iron splice on each side of the rail—has become standard in Europe and is gaining ground here. It is the lightest and strongest fastening that can be applied, when rails are high and properly shaped to receive it. The old difficulty of nuts jarring loose, has been overcome by the use of elastic washers. Fishing a pear-headed rail three or three and a half inches high, would be perfectly useless. For light rails, and for steel rails (to save weakening them by punching) and as an auxiliary to the fish-joint, the new Reeves' fastening—a tight clamp upon the contiguous flanges of two rails, is coming largely into use. The mere chair or seating for the ends of rails is no longer considered safe nor economical for lines of heavy traffic. Although there is room for farther experiment, it cannot be said that the demand for a good rail-joint has not been met.

Iron Rails.—Some of the early rails put down in this country on roads of considerable traffic, lasted over twenty years, most of this service having been under light vehicles, but upon indifferent road-beds. These rails finally *wore out*—they did not laminate to any great extent. We have the specifications by which these rails were made, and we know the quality of the material put into them. Good iron without any admixture of old rails, was welded under the hammer and then reheated and reworked until it was made fine grained and compact in the highest degree.

It is often asked why we do not get such rails now. The answer is that they are never called for. It does not appear from any accessible records, that such a pattern, or such a specification, or such a price, or such a service have been contemplated in any modern specification. The old patterns were very thin and elastic in the head. The pear-head was an abortive invention to work off bad iron. The old rails being low and sound, could bend without injury, but as this extreme deflection would keep modern heavy vehicles constantly traveling up hill, heavier rails have been specified; 60 and 65 lbs. instead of 40 and 45 lbs. to the yard, thus increasing the difficulty of manufacture and the stress on the material.

Better iron rails can be made now than were ever made before: first, because our knowledge of impurities, fluxes, processes, characteristics and requirements has been enlarged. More suitable and more uniform iron can be produced. Second, because forge and rolling-mill machinery is heavier and better than of old. Greater refinement and condensation and closer welds can be made by modern hammers and rolls.

But rails made from suitable iron, such as would be used for axles and forgings—rails rolled from hammer-welded and reheated piles—would cost nearly as much as steel rails. In fact, rails of ordinary iron with heads of puddled steel (which is a high wrought iron made from the best material) are sold at $115 per ton.

American railway managers, instead of offering anything like cost for good iron rails, have made themselves notorious by establishing as standard, a brand of rails known all over the world as "American rails," which are confessedly bought and sold as the poorest, weakest, most impure, least worked, least durable and cheapest rails that can be produced.* Although American made rails are usually better, and although the more enlightened managers willingly pay higher prices to home makers, yet the general tendency has been to reduce prices to the lowest possible point *irrespective of quality*.

No specification is made, no test institut-

* See report of A. S. Hewitt, U. S. Commissioner to the Paris Exposition.

Also see letter of Mr. C. P. Sandberg, to the "London Times," in "Engineering," Jan., 1869.

ed, no care taken, except to find the lowest bidder, and he may use all old rails, cut up and laid in the rail pile, without breaking down, reheating or admixture, if he can only make them stick together till they are delivered. This is what the rail maker is hired to do, and he does it openly, but under protest.

A leading railway president and reformer, Mr. Hinckley, of the Philadelphia, Wilmington & Baltimore railway, says:* "There is great fear on my part that railway companies will themselves tempt steel makers to send a poor article, by buying the cheapest—first cost only considered—as they did with the iron masters. It rests with railroad men to keep steel rails good by buying no poor ones."

In order to meet the demand for cheap rails, our iron masters have introduced a poison into our railroad iron, from the effects of which we shall very slowly recover. Under the pretence of making the heads of rails hard and durable, they have made them of a cold-short iron, impregnated with phosphorus. Now as it is notorious that rails go to pieces chiefly by lamination—by weakness of materials and welds, the hardness of the head is not much utilized. But the disease reaches its climax in the next generation of rails. The old rails are cut up, piled with raw iron and rolled into a new rail. The phosphorus is now distributed throughout the mass, contributing both to bad welds and to cold-shortness where strength is most required. One slab of good fibrous iron is indeed placed at the bottom of the pile to form the flange; but, to balance it, a layer of phosphorus is put on the head.

As long, therefore, as old rails are used promiscuously in the proportion of $\frac{1}{3}$ to $\frac{2}{3}$ with new iron, it is impossible to guarantee new rails against breaking and rapid lamination. When old rails are selected by the fracture, and rolled into bars before being piled; when the new iron is selected for its quality and not for its cheapness, and when the top slabs are welded by the hammer and then reheated and rolled, good rails may be made out of the materials at hand, but at a largely increased cost.

Inasmuch as railway companies are not always satisfied with the representations of rail makers, as to cost, quality, etc., a plan has been suggested whereby inaccuracies of this kind are not likely to occur. A specification of iron and manufacture is to be agreed upon and to be carried out under the inspection of the railway company's engineer. The actual cost as shown by the rolling mill books, together with a certain price (not a certain percentage—for obvious reasons) per ton for wear and tear and profit, to be the price of the rails. In this way it is not possible for the consumer to demand features for which he is unwilling to pay, nor for the maker to profit by working in poor materials.

There is a remarkable difference in the wear of iron rails on our different lines, and this difference is almost in exact proportion to their cost. When traffic is so light that good iron rails will last from seven to ten years, and when the money to buy a better material cannot be raised, as in case of many new lines, the question of better iron rails is of the greatest importance. But for lines of heavy traffic, like the New York Central, Erie and Hudson River, no iron rail, however made, can meet the demand. At something less than the cost of steel, an iron rail can be produced that will wear out instead of going to pieces in the welds; but it will be so much softer and less homogeneous than steel, that the latter will be as great an improvement upon good iron, as good iron is upon the bad iron now in use. The wear of steel *tyres* is three or four times greater than that of the best iron tyres. It would obviously be impossible to make an iron rail superior to a Lowmoor iron tyre.

(To be continued.)

THE LATE ORDNANCE COMMITTEE.

For "Van Nostrand's Magazine."

The late Joint Committee on Ordnance of both Houses of Congress was a body of men intrusted with the powers of Congress, representing the people and States of the country sitting in inquest over the acts of other public servants, and charged with the duty of enlightening Congress and the people as to the honesty and efficiency to be found in an important branch of the public service. The report they submit purports to be the unbiased verdict of six able men of high intelligence, having at their disposal unlimited sources of information, and the advice of all the experts in the world. The subject they are to investigate is one of peculiar interest, for it is a branch of special

* Letter of December 22, 1868, to Edward Austin, Esq., Boston. See "Van Nostrand's Engineering Magazine," for April, p. 367.

requirement upon the successful administration of which largely depends our military prestige, and, by consequence, the standing and respect we are entitled to among other civilized nations. It is to be fairly presumed the verdict of this inquisitorial body will carry with it great weight among those who look merely at its surface, and those who do so are the great mass of the American people, who keep themselves informed respecting the actions of Congress. The undercurrents are unfortunately hidden. The motives and the evidence are seldom seen. Since upon these turn the whole value and significance of such a document, and they being carefully kept out of sight, as far as practicable, the power for harm and the wreaking of private malice are boundless in the hands of such a committee; and, it may be added, the criminality of deliberate falsehood all the greater.

It was this same committee which, last year, brought in a damaging report against the Chief of Ordnance—Gen. A. B. Dyer—charging that officer with having availed himself of his high position for his own private advantage; of having received private emolument for furnishing ordnance stores of inferior quality when a better quality was being offered; of suppressing the records of the ordnance officer when called upon to furnish evidence, and other charges too numerous to mention. By implication they also assaulted the whole system of American ordnance, and the present constitution of our ordnance service. Under the circumstances, the Chief of Ordnance, who had not been permitted to appear by counsel before the committee, or even to know the drift and character of the investigation, instantly applied for a Court Martial, which was refused, but a Court of Inquiry afterwards granted, consisting of Gens. Thomas, Hancock, and Terry. This court is now near the close of its labors, which have been assiduous and almost unintermitted since last November. The counsel for the prosecution is Clifford Arrick, Esq., formerly an examiner in the Patent Office; subsequently the agent of a New York firm for the manufacture of a patent projectile (the Eureka), of which Arrick is nominally or really the patentee, and W. S. Kennedy, Esq. The counsel for the defence are David D. Field, Esq., of New York, Col. S. V. Benèt, and W. A. De Caindry. The investigation has been most exhaustive upon all the points brought up by the committee. The first volume (a formidable one), and advanced sheets of the second are before us, and we have read them with great interest.

The main points established by the evidence—established, in great part, by the testimony extorted from the prosecutors, beyond a shadow of question, are:

1st. The committee was chiefly constituted of members utterly hostile to the Army in general, and to the Ordnance Department in particular.

2d. The examination was conducted at the instigation of a ring of disappointed contractors, chief among whom were Clifford Arrick, Norman Wiard, and Horatio Ames, and who were allowed every facility and license for entering testimony.

3d. That all persons sympathizing with, or interested in the Ordnance Department, were carefully kept in ignorance of the specific objects of the investigation, and from a full knowledge of the testimony; copies being refused to Gen. Dyer, as well as counsel to represent him, in an examination where the plaintiffs were superabundantly represented.

4th. The mutilation of evidence, the suppression of important facts and interpolation of ideas never intended to be conveyed—done chiefly by this same Arrick, who was clerk !! to the committee, and intrusted with the task of *systematizing* and "boiling down" the evidence, as he expresses it.

5th. That Gen. Dyer has not been pecuniarily, or otherwise personally interested in any contract or official transaction, nor is there the remotest trace of evidence that he ever received any benefit from any official transaction, or suppressed any evidence.

6th. That the report abounds in assertions and criminations, which the evidence, garbled, distorted, and prejudiced as it is, does not warrant under the most unfavorable construction.

7th. The final report of the committee was framed, drawn up, and written entirely by Clifford Arrick, as he himself acknowledges.

The proof of the first point will be perfectly clear by mentioning the names Butler, Schenck, Logan, and Howard. Senators Drake and Cameron were on the committee, but were seldom in the committee room, and had no share in it beyond a silent assent.

The proof of the second is in the correspondence between Ames and Arrick, which was before the court, and contained the details of the conspiracy and reports of progress.

The proof of the third appears in the testimony of Mr. V. E. Smalley, a clerk of the committee, which is perfectly explicit, and in the correspondence between Senator Howard and Gen. Dyer.

Of the 4th, the following is a single specimen out of many; being in relation to an attempt to show that Dyer was the real patentee of the Absterdam projectile, and Absterdam only the ostensible patentee:

Q. to Absterdam by Arrick: "I desire to know whether, in answer to a question put to you before the Joint Committee, you did not say, 'In reality I am not the inventor of two shells, but I am the maker of two shells, known separately to the Ordnance Bureau?' " * * *

Answer. "I wish the court to allow me to state that that evidence of mine in this book is mutilated; that evidence is a forgery; that evidence is manipulated to read differently from what it ought to; other words have been substituted for the ones I used in my testimony. I repudiate it. I said, "In reality I am not ONLY the inventor of two shells, *as I have three patents for improvements in projectiles*, but I am the maker of two shells known separately to the Ordnance Bureau.' " * * *

Q. "When did you write that down in the manner you have just read?"

A. "This morning, sir"

Q. "Who suggested that to you?"

A. "I suggested it to myself before I came here to Washington, when I read the evidence in New York. I was so disgusted with it, I meant to have the matter known if I only had an opportunity. That is not the only specimen. If I were allowed to digest it, and if I had the time, it would make a different story, so far as my evidence is concerned." [Mr. Absterdam then points out three more instances of flagrant mutilation.]

The reports of officers upon the relative merits of the Eureka and other projectiles, upon which important matters were made to turn, and charges based, were shown to have been grossly perverted in the hands of the committee by the production of originals in evidence before the court.

With respect to the 5th point, it will suffice to say that the prosecution do not even attempt to show that Gen. Dyer ever received any benefit from official transactions, and as for the suppression of evidence, the charge was shown to be as cool a piece of deliberate falsehood as we ever heard of.

As to the 6th, we have not room to specify, but can promise the most absolute proof and satisfaction in referring the inquirer to the record of the court.

Arrick's own testimony is categorical respecting the seventh point.

It is to be regretted that the inquiries of the court cannot be extended also to the *recent* report of this committee. But the exposure of the animus of the first report may discredit also the second, and possibly a brief examination of the latter may serve to put it into its proper connection. It seems that Messrs. Arrick, Wiard and Ames, after their success in getting Gen. Dyer in limbo, proceeded to the next step, viz: a more sweeping and explicit indictment of the whole Ordnance Department, and a condemnation of its material. So far as the committee could help them, they succeeded here also. The third step—their abolition and a substitution of a regime of their own—a Board under control of civilians (*i. e.*, of Arrick and Wiard), has not yet been taken and is not likely to be.

I. The report (February 15th, 1869), begins by the astonishing statement that the increase of calibers necessitated by modern warfare has "developed a remarkable and puzzling fact, viz: that systems of fabrication which, with small calibers, gave good endurance, when applied to large guns, proved to be failures." The committee, it seems, wish to express their ignorance of the first ground rule of constructive mechanics, that with an increase of dimensions the strains increase in a higher ratio than the strength—a principle as applicable to guns as it is to girder bridges. Thus, other things being equal, the intensity of the force of the powder will bear a definite ratio to the length of the shot. This force, acting upon a long shot, has to overcome the inertia of a greater amount of metal per square inch of surface in the base of the shot than when acting against a short one. Since an increase of caliber involves an increase of length in the projectile, the intensity or amount per square inch of explosive force increases accordingly. *How "puzzling!"*

The report proceeds:

"Elaborate experiments, stretching over a period of years, have been carried on in Europe and America to solve this problem, and many new systems which in theory promised success have been successively tried and abandoned, nearly all of them succeeding in small guns but failing in large ones, and failing, too, in a manner which increased the complications of the problem—a gun frequently enduring over 2,000 rounds, while another, precisely similar, would explode after a few fires—while guns made of the strongest material seemed generally to prove the weakest when put to the test. No nation at present has guns of large caliber, the endurance of which can be estimated with any degree of certainty. This difficulty, serious enough with smooth-bore guns, is greatly increased in rifles, the 30-pounder being the largest rifled gun that has exhibited even comparatively good endurance in this country, *while in Europe no more satisfactory result has been obtained*."

According to their own showing then, although thousands of dollars have been expended in Europe on ordnance experiments where one has been expended here, and though Europe has machinery which this country will not have for many years to come, we are, after all, *not behind* any nation in the world in respect to ordnance. Speaking of "strongest materials" proving weakest, the committee, I presume, refer to wrought iron and steel—metals not used by the Ordnance Department, except the former for the 3-inch rifle. We thank the committee for this unintentional assent to our practice, which is the use of cast iron. Touching the remark upon the inequalities of endurance of similar guns, we are very curious to know upon what evidence this assertion is founded. Imperfections are as liable to creep into individual guns as into any other mechanical contrivance, in which case the cause of failure may be discerned by inspection. Lastly, the value of the assertion that no nation has a reliable system of heavy ordnance turns upon the word "reliable." If it means that no system has been devised by which we can warrant a long life to every gun fabricated on it, whatever the size, as a mathematical certainty, we assent. The committee might also have suggested, in the same connection, that we have no "reliable" steam boilers, no "reliable" ships, no "reliable" railways—in short, that the millenium has not come. There is no more reason why an infallible gun should be expected of the Ordnance Department than infallible wisdom from an ordnance committee. We have no objection to a comparison of fallibilities. We hope to show before we are done that if our guns are not absolute perfection, and do not preclude the possibility of improvement, they are decidedly superior, in respect both of power and durability, to those of any other system of ordnance in any nation of the world.

II. The report then proceeds to state that the idea that rupture is produced merely by the explosive force of the powder is an error, "as is shown by the fact that the pressure of powder has been found to be uniform, as it gives a uniform range to the projectile, and at times does not burst a gun made of weaker material than others which have burst when fired with like charges." This is mere ignorance on the part of the author of the report. The pressure has *not* been found to be uniform, or anything like it. It is subject to the widest variations, not only as between guns of different calibers (which is obvious enough on principle), but as between guns of the same caliber and pattern. Uniformity of range does not by any means warrant the inference of uniformity of pressure. Indeed, this pressure is regulated by the grain and quality of the powder, and the grain may be so selected that in the average results of an indefinite number of trials, all degrees of pressure may be obtained at will between widely separated maxima and minima limits, while the range remains constant. But in rifled guns there is another source of variation, even with identical charges, viz: the enormous friction of the shot against the bore, to which may be added the length of cartridge and the unequal times required for complete ignition. All practical artillerists, who are well acquainted with experimental firing, are familiar with these causes and know the existence of wide variations in the pressure, as indicated by the pressure gauge. The following citation from experiments made at West Point on a 100-pounder Parrott (see "Holley's Ordnance and Armor," pp. 478–481), illustrates the matter:

CHARGE 10 LBS. OF POWDER; ELEVATION 5 DEGREES; PROJECTILE $99\frac{1}{2}$ LBS.

No.	Powder.	Range.	Pressure.
1	Dupont 7	2,078	38,000
2	Dupont 7	2,180	45,300
3	Hazard 7	2,251	80,000
4	Hazard 7	2,308	86,000
5	Bennington 5	2,221	27,500
6	Hazard cake	2,370	114,000

CHARGE 10 LBS.; ELEVATION 15 DEGREES; PROJECTILE 100 LBS.

No.	Powder.	Range.	Pressure.
13	Dupont 7	4,830	32,630
15	Hazard 7	4,911	48,700
17	Dupont 7	4,796	60,350
18	Dupont 7	5,030	64,000
20	Hazard 7	4,735	99,002
21	Hazard 7	5,045	102,980

These two selections are but samples of what may be found in every experimental record with rifled guns. They show conclusively that range alone is no measure of the pressure. As the committee cite no other "facts" to sustain their assertion we fairly infer that they have none to cite.

III. After mentioning the various European systems and pronouncing them failures, the report declares the Rodman guns failures with the rest, and in proof quotes the report of the Chief of Ordnance of the Navy, who says:

"Opinions differ quite as widely in regard to the preferable mode of developing ordnance power, whether it shall be by smooth or rifled bores, by loading at breech or at muzzle, made from iron, cast or wrought, or from steel, solid or in connected parts. The relation of mass to velocity is also unsettled. In fact the question involves the necessity of going back to fundamental principles, and starting thence by well conducted experiments."

In other words, the statement of the Chief of Ordnance of the Navy, that "opinions differ as to the best mode of developing ordnance power," is proof that the Rodman guns cannot do what is expected of them. Really Jack Bunsby's logic is getting to be very commonplace.

IV. The reader will, therefore, appreciate the force of the remarks which follow this profound criticism of the expert committee:

"It, therefore, appears that, notwithstanding a long series of experiments extending over a long period of years, and the practical experience of our recent war, the ordnance officers of the government have not yet determined upon even the fundamental principles of their art, and possess no positive knowledge of the problem they have so long sought to solve. Mechanics is an exact science, and ignorance of that branch of it involved in the construction of guns would seem to show either want of knowledge of its principles, failure to understand their application, or superficiality of investigation, surprising in men whose minds have been from boyhood trained in the direction of a specialty."

These remarks are highly edifying, coming as they do from a committee, who begin their report by confessing ignorance of causes of failure in large guns as distinct from small ones,—assert that rupture is not due to the expansive force of powder alone,—that range is a measure of the pressure, and that the Rodman guns are failures because the Chief of Ordnance of the Navy says "opinions differ as to the best methods of developing ordnance power!"

In support of the assertion that each system of guns introduced has failed in practice, General Gilmore is represented as reporting that while only twenty-two large guns were mounted at Morris' Island at one time, fifty in all burst during the siege. This is not true. That report states that twenty-four burst, and this number includes a 30-pdr. which had been fired 4,606 rounds at a high elevation,—the most remarkable test, doubtless, on record, of any gun,—and several 100-pdrs. which had been fired more than one thousand rounds—an ample endurance for any rifle of that caliber. We shall speak of the Parrott guns further on.

The statement that Admiral Porter declared that all the Parrott guns used in his fleet to bombard Fort Fisher had burst is, we believe, literal; but the gallant Admiral, as the committee might have known, and probably did know, officially retracted this statement, and paid a high tribute to them on a subsequent occasion. However that may be, how do the committee sustain the charge of failure upon *all* systems when they have only attempted to quote the record of the Parrott system?

V. The next step is an attempt to show that the rupture of guns is due to molecular tension, caused by the heat of rapid firing, which, they say, assists the explosive force of the powder. Here, gentlemen, readers of the "ECLECTIC," is the "cat in the meal." To nine-tenths of you probably this startling hypothesis is no stranger. The pertinacity and self-assurance with which it has been urged by its author, has not allowed many people to remain in ignorance of it. After years of untiring solicitation, of persecution of every variety of government official; in spite of the reticence, or patient refutation, or ridicule, or snubbing, according to the temperament of individuals, which he had always encountered, he has persisted in urging it, and has at last found two advocates. One is Mr. Benj. F. Butler, and the other the editor of "The Tribune." We congratulate Mr. Norman Wiard. He has hit upon the persons of all others best qualified to champion this new revelation of his, which is to overturn all the systems of warfare now in vogue throughout the world. Surely the brilliant projector of the Dutch Gap canal, of the Fort Fisher powder boat, and the advocate of Col. Serrell's flying machine, is, of all men, the one best qualified for, and congenial to the task of convincing the world of Mr. Wiard's heat theory. We regret it should ever be necessary to speak seriously of such a matter. But it is useless to deny that Mr. Norman Wiard, the laughing-stock of every expert and engineer who has heard his name (and most of them have), is one thing, and Norman Wiard, wielding the thunder of a great Joint Congressional Committee, is another. We decline to enter into any discussion of his foolish hypothesis, but we are forced to admit or deny the statements the committee have published for him.

(1.) It is stated that the conditions of rapid firing, which often occur in service, do not appear to have been realized in experimental firing, and therefore the destructive effects of heat have escaped the notice of experimenters. This is untrue. In 1863, comparative trials of banded and unbanded guns were made by direction of the Ordnance Department, and the effect of rapidity of firing was one of the specially designated objects of the investigation. These guns were, therefore, fired more rapidly than has ever been practicable in action, ranging from 93 to 140 rounds in two hours, and nothing whatever was developed to show that heating rendered them liable to burst. In the report of the siege of Charleston, General Turner states that after his officers and men had become experienced, the machinery of the carriages working smoothly, the 100-pounder could be fired once in 5 minutes, the 8-inch rifle once in 7 or 8 minutes, and the 10-inch rifle not oftener than once in 10 minutes. Eight rounds per hour is rapid firing for sea-coast guns. In experimental practice, the 100-pounder has been fired 20 rounds in 2 hours; the 8-inch rifle, 24 rounds in 2 hours 20 minutes; the 10-inch, 25 rounds in 2 hours 20 minutes. After the disaster at Fort Fisher, three 100-pounder rifles used in that action were fired 1,000 rounds each by direction of the Naval Investigating Committee, with a view of ascertaining, if possible, the cause of the bursting of the guns in that action. These guns all stood the test, and were fired during a large portion of the trial with greater rapidity than could possibly have been obtained in action, because no time was lost in sighting. Rapidity of firing has often been the subject of experiment where guns have been put to extreme proof.

(2.) The committee speak of the effects of the cooling of red-hot wrought-iron, of the strains inaugurated in the cooling of molten iron, &c., &c. As we see no connection between these hackneyed facts and the behavior of guns under fire, we omit to notice them further.

VI. The spontaneous rupture of guns is alluded to. This occurs sometimes in very large castings where certain grades of iron are used. So far as guns are concerned, it is liable to occur under bad management or carelessness whether the gun is cast solid or hollow. But every iron founder is well aware that there are some grades of iron too high for guns. It is not that which gives the highest tensile strength which is best suited for gun metal. The requisite material must have also a high degree or modulus of elasticity. The selection of the proper grades and qualities is a matter of extreme delicacy, and only the most perfect accuracy can insure the result. From the waste metal of every rough gun are taken test specimens, which are tested by the proper machinery as to their precise qualities, and any unusual deviation from the experimental standard subjects the gun from which it is taken to extra proof, or possibly even to rejection without trial. But it is satisfactory to know that such deviations seldom occur. When they do occur, it is not to be wondered at that the disturbance of the relations of molecular forces should manifest itself in spontaneous rupture. If the committee will obtain the passage of a law of Congress so altering the atomic constitution of elementary matter that it shall not deviate from standard behavior, and agree to enforce it, the Ordnance Department will no doubt consent to adopt the metal thus provided.

VII. We now come to the culminating point of the report:

"The fact that the ordnance officers of the Government find it necessary, at this late day, to return to the rudiments of their art, * * * shows a defect in the organizations of the Ordnance Departments calling for a remedy. The difficulty appears to have been two-fold; first, the ordnance officers, knowing their positions secure to them for life, have not felt the incentive to exertion and improvement which stimulates men not in the Government employ, and they have become attached to routine and to the traditions of their corps, jealous of innovation and new ideas, and slow to adopt improvements. An illustration of this is found in the fact, that the late war was fought with muzzle-loading guns (with the exception of carbines for cavalry), although a variety of excellent breech-loaders were urged upon the attention of the Government constantly, and the honor was reserved for Prussia, with a weapon inferior to many American inventions, to demonstrate the immeasurable superiority of breech-loading guns."

The charge of undue conservatism we shall not notice, further than to say, it is quite true with respect to the "improvements" urged by Mr. Wiard. That conservatism still exists, and we venture to prophesy that it will continue to exist when the humble writer of this notice gets to be Chief of Ordnance, at some dim distance in the future.

The "illustration" contains the same amount of falsification as many others. Primarily, the report speaks of the substitution of breech for muzzle loaders, as if it were a matter for instantaneous decision, involving no grave responsibilities. In the year 1860 no nation, and it is probably safe to say few individuals, thought of the general use of breech-loaders for infantry. Early in the war quite a number of infantry regiments were armed with the best breech-loaders known, and after a trial the advantages failed to appear. The first good breech or "magazine" loader offered was the Spencer. Numerous regiments were armed with it in the year 1864, perhaps earlier, and its merits in the hands of experienced troops were found to be decided. Every Spencer that could be obtained was taken by the Department for arming the cavalry, where its advantages were much more conspicuous than in the infantry. But the whole system of breech-loaders was so hedged in by patent rights, and these rights so powerfully backed up by political influence, that a general armament of the troops with these weapons was out of the question. Still the necessity for breech-loaders and their ultimate adoption was fully recognized by the Ordnance Department, and in 1865, the end of the war being felt to be near, vigorous steps were instantly taken for their supply, freed as much as possible from the insuperable clog of patent rights. The result has been the adoption of a breech-loader which the Department claims to be superior, by many degrees, to any in the world, and unhampered by the claims of patentees. Looking back with convictions now universally entertained, it is easy to ask, why were not these muskets adopted at the outset? *Going* back and looking forward we may reply, because no living man can predict any advantage for them. There was just one course to be followed in the premises — to select the most promising breech-loader, put it into the hands of the best regiments, and abide by the result. And this is precisely what was done. So far from Prussia setting us the example, Prussia had the benefit of our experience. Was anything heard in Europe before Kœniggratz of breech-loaders? Before that great day they were known and recognized here.

The report continues:

"In the second place, these officers, educated to a specialty and proud of their positions, come to look upon themselves as possessing all the knowledge extant upon the subject of ordnance, and regard citizen inventors and mechanics who offer improvements in arms, as ignorant and designing persons and pretentious innovators, who have no claim to consideration. Instead of encouraging the inventive talent of the country, these officers seem to have constantly discouraged it, and many complaints of improper and oppressive treatment have been laid before the Committee by persons who have sought to draw the attention of the proper authorities to what were supposed to be vital principles connected with their art."

It will be observed that Mr. Wiard speaks from bitter experience, and we could name others who probably have similar complaints to make.

"Another difficulty that has retarded progress in the science of ordnance has been the fact that prominent officers have been inventors of arms, and have possessed sufficient influence to secure the adoption and retention in service of their inventions, frequently without regard to the question of real merit, and to the prejudice of other and better devices brought forward by citizens or developed in other countries."

We are familiar with nearly every article used in the ordnance service—certainly with all important articles. A quarterly return of ordnance stores from some of our arsenals has been known to embrace some 12,000 to 13,000 different names of articles. We have spent some time in looking over the list also. As the result of our examination, we are unable to find any article upon which any ordnance officer is interested pecuniarily, in any way, by patent or royalty, directly or indirectly, unless, indeed, in some small item, unaccounted for, which will be stopped against the accounting officer's pay, when the Auditor gets hold of the vouchers. Gen. Rodman *did* have a patent on his method of casting guns, which he sold for a royalty to Chas. Knap, of Pittsburg, in 1847. The patent expired in 1861, was renewed for seven years, expiring again by limitation in 1868, and has not, I believe, been since renewed. As long ago as 1861, a hue and cry was raised against the Rodman patent, and when the petition for renewal was brought before Congress, a committee of investigation was appointed, consisting of Hons. Robert Dale Owen and Joseph Holt. The result was that Gen. Rodman's right to the patent was fully sustained and the renewal granted. We have known of a few instances where patents for ordnance stores have been taken out by ordnance officers, but the articles were not adopted by the Ordnance Board. The sentiment and practice of the officers of the corps is against patenting any improvement, excepting where the inventor has been put to great private expense for its perfection, though *the right* to do so is maintained.

VIII. We now come to some statements of "fact" which, with much falsehood, have a measure of truth in them, though, by their arrangement and juxtaposition, they are made to yield inferences as false as any others, showing that, although figures do not lie, men will sometimes lie tremendously about figures.

"Great diversity exists in the two branches of the service, respecting the arms adopted and the manner of proving, mounting and using the same. The calibers, models, chambers and ammunition of the navy guns are entirely unlike those in use in the army. For example, the navy 12-pounder boat howitzer has a caliber of 3.4 inches, while the army 12-pounder guns are of the calibers of 3, 3.2, 3.67 and 3.8 inches."

There is but one army 12-pounder now in service, and that is 4.62-inch caliber. Of the guns referred to, the only ones having the designated calibers are the 3-inch rifle, which, it is true, fires a shot weighing somewhere near 12 lb.—*i. e.*, $9\frac{1}{2}$ to $11\frac{1}{2}$ lb., and the 3.67-inch or 20-pounder Parrott. Surely no human being ever before thought of calling these guns 12-pounders. The 20-pounder Parrotts were seldom used except as siege guns, though they were not uncommon in the navy. There is a discarded "12-pounder," that is Mr. Wiard's own, though he does not mention it. Specimens can be seen at our arsenals, put up among the "nondescripts" to illustrate the freaks of inventive genius.

"The models of the two guns are entirely different, so that neither could be used on the carriage of the other. The system of sighting is also different. A gunner in one arm of the service, without special instruction, could not use a gun belonging to the other, one being graduated to seconds of time of the flight of the shot, the other to degrees of elevation."

We would also add for the benefit of the uninformed, that the navy guns are also unprovided with horses, and the sailors are without picks or shovels, and even caissons and battery wagons are wanting in the naval armament. Seriously—if it is possible to be serious—what do the committee mean by "using either gun on the carriage of the other." What kind of service, and on what element do boat-howitzers perform, or are field guns used? What does Jack want of a pendulum-hausse when sighting his gun among the waves, or a soldier of a time-scale on land?

"It is impossible to use navy ammunition in an army gun, or army ammunition in a naval gun."

That being the case we should by all means advise the navy to use their own ammunition exclusively, and we tender the same advice gratis to the army. Yet it is freely acknowledged by ordnance officers that the advantage of a uniform system *in the higher calibers* is a fair subject for discussion, to say the least, though the disastrous consequences of a lack of it is the veriest bugbear. Not pretending at all to "speak by the card" in this matter, I yet venture the surmise that army ordnance officers are more than willing: I know nothing about the navy opinion. The 20 and 15-inch guns are nearly conformable already.

IX. In presenting their conclusions the committee say that

(1.) "No more heavy guns should be purchased" at present.

(2.) "The Rodman system, while partially successful in smooth bores and small calibers, has so far failed in rifles of larger caliber as to show it to be unworthy of further confidence. * * * The principle of initial tension, which is the basis of the Rodman system, appears to be of doubtful utility, especially for rifled guns. This tension, it is admitted, gradually disappears with age, and is finally entirely lost."

We are curious to know, if the Rodman smooth bores are "partially" successful, what a complete success would be. We have before us a list of cannon, "burst or otherwise failures, in the national service" since 1860, published in the "Tribune" of April 5th, as we have reason to believe by Mr. Wiard. It is "prepared from reports and evidence before the Joint Committee on Ordnance." The recapitulation states that twelve 15-inch Rodmans were disabled. Looking over the "full catalogue" we do not find any specified, and we are morally certain there have never been any such disasters to specify. The recapitulation contains six 15-inch Rodmans self-burst; the catalogue specifies only three. As these burst before they were inspected, and, therefore, were not in the national service, they do not belong to the list. One 13-inch Rodman is specified as bursting at the 738th fire—a fair endurance for that caliber. Here, then, we have *one gun* out of the thousands built on the Rodman plan for smooth bores which has burst, and that after a fair endurance, and this upon the committee's own *ex parte* evidence. We hope we shall live to see a *perfectly* successful gun according to the idea of the committee.

The recapitulation specifies eleven 10-inch and 12-inch rifles on the Rodman plan as disabled. The catalogue specifies one 8-inch (the first one) at 80 rounds, and one 8-inch at 1,047 rounds—a very fine endurance—and one 12-inch at 470 rounds. This last gun was burst by the breaking and wedging of the shot in the bore, the pressure gauge showing a force of 135,000 lbs.! at the final discharge. Two other 12-inch rifles are "reported injured," but their injuries have never been heard of at the ordnance office. Nothing has yet transpired to discredit the Rodman rifles. Indeed their prospects are most hopeful. But few experiments have been made with them, and they are counted only as experimental guns. A sudden stop was put to all trials at the instigation of the committee, and the appropriation asked for to continue the experiments refused. This is the whole evidence upon which the Rodman system is pronounced a failure.

(3.) "Guns cast solid in the manner practiced in the navy under the direction of Admiral Dahlgren, while exhibiting satisfactory endurance as smooth bores, with small charges and hollow projectiles, have not the requisite strength for rifles of large caliber. This mode of casting seems to be defective in principle, as the tensions inaugurated in cooling have a tendency to aid the powder in rupturing the gun."

The Dahlgren guns need no defence. The wry faces made at them cannot be construed as an assault, and the only reply which can be made is to point to the record of the IX and XI in smooth bores.

A word or two about the Parrott system. It is useless to assert that these guns have proved perfectly successful. That, however, has little to do with their relative merits. The whole world is challenged to produce a large caliber rifle which has on the whole sustained so good a test. The English Armstrongs and Whitworths have shown no such average endurance, nor have the steel guns of England and Prussia. They are the only rifled guns in this country whose merits are known, and their record has on the whole been very good. Every experienced artillerist who has dealt with the 6.4, and 8 inch rifles can recall some instances of failure, but his confidence in them has been justified thousands of times where it has been shaken once. The unusual number of failures at Morris Island is ascribed to peculiar local causes. The fine and ever-drifting sand was blown perpetually into the muzzles of these guns, and with the lubricant and residuum of the powder formed a scale in the bore, which had to be removed with a steel chisel. Most of the failures occurred at the sand battery where this difficulty was greatest, while those having a marsh in front experienced scarcely an accident. Another alleged cause was the explosion of shells in the gun, generally by concussion, a disaster frequently occurring and which there seems to be no known method of preventing altogether. This is probably the chief obstacle to be overcome in rifle guns of large caliber, viz: a projectile that will leave the gun without breaking. The pressure gauge reveals the terrible danger of such a mischief, running up the pressure to 130,000 and 150,000 lbs., which is sure destruction to any gun which ever has been or ever will be made.

In reviewing the various systems of gun-making, the committee seem to have adopted the exhaustive process of argument. No guns made in Europe are of any value; of the guns made in this country neither the Rodman hollow cast, the Dahlgren solid cast, nor the Parrott banded guns, can be trusted. Wrought iron and steel are utterly condemned, and having exhausted every known or conceivable device, *with one exception*, we are categorically drawn to that exception. There is one system having no likeness to any other, and which the committee have indirectly countenanced, viz: Mr. Norman Wiard's. The record of Mr. Wiard's gun designed to obviate the destructive effects of heat is as brief as Cæsar's epigram—one gun, *one round*, many pieces.

But we must bring this paper to a close by one more revelation. Though morally certain of it, we do not assert that Mr. Wiard wrote that report. But we do assert that if he had been called upon to write one he would have written one substantially identical. In the supplement to the report of the Committee on the Conduct of the War, Vol. II, 38th Congress, 2d session, Senate Mis. Doc. No. 47, is a communication from Norman Wiard containing the same misrepresentations, groans, croakings and abuse of ordnance officers as appear in the committee's report, and in the same phraseology. Wiard's testimony contains the substance of the report, indeed the report is merely Wiard's testimony sand-papered. As Arrick wrote the other, why should not Wiard write this one? Lastly, we have it from high authority that at the direction of Senator Howard both Gen. Rodman and Admiral Dahlgren sat each a whole day to be pumped by this man, who put the questions, took down the answers, and probably "boiled down" the testimony as well as wrote the report.

As I have advanced no theories, but stated only matters of official record (except in one or two specified cases), the readers of the ECLECTIC will perhaps be able to form some notion of the unique character of this report. D.

STRENGTH OF SCREW SHAFTS.

A Paper "On the Calculation of the Stress in Propeller Shafts," read by W. J. Macquorn Rankine, C. E., LL. D., F. R. S., at the Institute of Naval Architects, March, 1869.

(1.) Through a long series of practical trials, extending over many years, it was ascertained by Lieutenant David Rankine (h. p. Rifle Brigade), and by the author of this paper, that the greatest stress which the wrought iron axles of very smooth-running railway carriages, traveling at speeds not exceeding twelve miles an hour, would safely bear, when made of the best materials and in the best way, was 9,000 lb. on the square inch (or about 6.3 kilos. on the sq. millimeter). Any defect in materials or workmanship, when exposed to that stress, was always found to cause the axle to give way in the end, though sometimes not until it had run for more than three years. The immediate breaking stress was not directly ascertained, but it is probable that the factor of safety was between five and six. A greater factor of safety, or, in other words, a smaller limit to the intensity of stress, is of course required when the motion is rougher than it was in those carriages.

(2.) According to the ordinary method of calculating the greatest stress in propeller shafts, the moment of the twisting action upon the shaft is alone taken into account; and when that method is applied to examples taken from actual steam vessels, results are obtained approaching very near to the limit already stated. For instance, 8,000 lb. to the square inch is a not uncommon value of the intensity of the stress in a propeller shaft, as calculated from the twisting action alone.

(3.) But the real intensity of the stress is greater still, for with the twisting action there is always combined more or less of a bending action, produced partly by the weight of the shaft and partly by its reaction when the vessel pitches and heaves with the waves. The object of the present paper is to give rules for calculating the total or resultant stress produced by the twisting and bending actions combined, and to illustrate them by an example.

(4.) TWISTING ACTION.—The *greatest twisting moment* is to be calculated from the indicated horses' power of the engines, as follows: Multiply the power by 33,000, in order to reduce it to foot-pounds per minute, and divide the product by 6.2832 times the number of revolutions of the shaft per min. The quotient will be the *mean twisting moment* in foot-pounds (for kilogrammeters the multiplier is 4,500 instead of 33,000). The *greatest twisting moment* is greater than the mean twisting moment in a ratio which may be estimated at about 1.6 for a single engine, 1.11 for a pair of engines with cranks at right angles, and 1.05 for three engines with cranks at equal angles.

When British measures are employed, the greatest twisting moment having been computed in foot-pounds, is to be multiplied by twelve to reduce it to inch-pounds.

To find the *greatest intensity of the stress produced by twisting*, multiply the greatest twisting moment by $\frac{16}{\pi}$ (= 5.1 nearly), and divide by the cube of the diameter of the shaft. In symbols, let M be the moment, d the diameter, and q the *twisting stress*, as it may be called. Then

$$q = \frac{5.1\,M}{d^3} \quad \ldots \ldots \quad (1)$$

(5.) BENDING ACTION.—The greatest stress produced on the particles of a horizontal cylindrical shaft by the bending action of its own weight is equivalent to the weight of a column of iron whose height is a third proportional to the diameter and the span between the bearings.

In symbols, let l be the span between the bearings (in inches if British measures are used); d the diameter; w the heaviness of iron (= .278 lb. per cubic in., or 7,690 kil. per cubic meter); p the greatest *bending stress*, as it may be called. Then

$$p = \frac{w\,l^2}{d} \quad \ldots \ldots \quad (2)$$

The *reaction* of the shaft produced by vertical oscillations, as in pitching and heaving, bears the same proportion to its weight that half the extent of the oscillations bears to the length of a pendulum which keeps time with them. Let m be that proportion; then the bending stress is increased to

$$p = (1 + m)\,\frac{w\,l^2}{d} \quad \ldots \quad (3)$$

In a vessel that follows the vertical heaving of the waves the value of m is nearly the sine of the wave slope—say, 0.25 in extreme cases, and 0.125 in ordinary cases.

(6). Resultant Stress.—The resultant stress due to the twisting stress q and the bending stress p combined, is found by a formula which has been demonstrated by writers on the internal equilibrium of elastic solids; that is to say,

$$s = \sqrt{\left(q^2 + \frac{p^2}{4}\right)} + \frac{p}{2}, \quad . \quad . \quad (4)$$

where s denotes the intensity of the resultant stress.

(7.) Numerical Example.—In the following example the results are not computed beyond four significant figures.

Indicated H. P.	5,500	
Multiply by..........	33,000	
Divide by ...... 6.2832)	181,500,000	ft.-lb per min.
Revo. per min ......54)	28,890,000	quot'nt nearly.
Mean twisting moment .	535,000	foot-pounds.
For a pair of engines multiply by........	1.11	
Greatest twisting mom't	593,850	foot-pounds.
Multiply by..........	12	
	7,126,200	inch-pounds.
Multiply by..........	5.1	
Diameter, 16½ in. ......)		
Diameter ³ ....4,492)	36,340,000	produet.
Twisting stress, q = ...	8,090	lb. on sq. in.
Span between bearings..	25 ft. = 300 in.	
Divide by diameter .... 16½)	90,000	square of span.
Third proportional.....	5,455	inches.
Multiply by weight of a cubic inch of iron ...	0.278 lb.	
Bending stress by weight alone	1,516 lb. on sq. in.	
× estimated value of 1 + m, say..........	1⅛	
Bending stress by weight and reaction = p =..	1,704 lb. on sq. in.	

Resultant Stress.

$s = \sqrt{\left(q^2 + \frac{p\,2}{4}\right)} + \frac{p}{2} =$ 8,987 lb. on the square inch, being practically equal to the greatest safe stress of 9,000 lb. on the sq. in., mentioned in sec. 1, as applicable to smoothly running railway axles at low speeds.

(8.) It seems very probable that if the method of calculation now described were applied to actual examples of propeller shafts, many instances would be found in which the resultant stress reaches, or even goes beyond, the utmost limits consistent with safety; and it is therefore laid before the Institution for their consideration, and for that of shipbuilders and marine engineers in general.

(9.) Rules for Designing Shafts.—The conditions which the diameter of a shaft ought to fulfill are expressed by the following equation, derived from equation 4:

$$s^2 - s\,p - q^2 = 0; \quad . \quad . \quad . \quad (5)$$

in which, for s, is to be put a safe working value of the resultant stress (say 8,000 lb. on the sq. in., or 5.6 kilos. on the sq. millimeter), and for p and q, their values in terms of M, l, w, and d, as given by equations 2 and 1 respectively. The equation then becomes of the *sixth order*, and it is to be solved so as to find d. This can be done by approximation only; and a convenient method of approximation is as follows: Assume for q an approximate value q^1, somewhat less than that of s (say, $q^1 = 0.9\,s$). Then calculate an approximate value d^1 of the diameter from equation 1, viz.,

$$d^1 = \left(\frac{5.1\,M}{q^1}\right)^{\frac{1}{3}} \quad . \quad . \quad . \quad . \quad (6)$$

Then calculate for p an approximate value p^1 from equation 3, viz.,

$$p^1 = (1 + m)\,\frac{w\,l^2}{d^1}\,; \quad . \quad . \quad . \quad (7)$$

and from the approximate value of p^1 calculate a second approximate value of q as follows:

$$q^{11} = \sqrt{(s^2 - s\,p^1)}. \quad . \quad . \quad . \quad (8)$$

Should this agree with the first approximate value q^1, the approximate diameter d^1 will answer; and should there be a difference, a second approximation d^{11} to the required diameter is to be computed as follows;

$$d^{11} = d^1 \left(\frac{q^1}{q^{11}}\right)^{\frac{1}{3}}. \quad . \quad . \quad . \quad (9)$$

When, as is usually the case, the difference $q^1 - q^{11}$ is small compared with q^1, the following formula for the second approximation is sufficiently near the truth:

$$d^{11} = d^1 \left\{ 1 + \frac{q^1 - q^{11}}{3\,q^1} \right\} \quad . \quad (10)$$

A third approximation might be found by repeating the process, but the second approximation will in general be found accurate enough for practical purposes.

Should q^{11} prove to be greater than q^1, the correction in equation 10 becomes negative; that is, the second approximation to the diameter is less than the first.

(10.) Example of the Rule.—$l = 300$ in. as before.

Twisting moment $M=$	7,126,200	in.-lb., as before.
Multiply by.........	5.1	
Divide by $q^1 = 7,200$)	36,340,000	product.
First approx., $d^{1\,3}=$..	5,047	
" " $d^1 =$..	17.15	inches.
Divide by $d^1 =$ ...17.15)	90,000	$= l^2$, as before.
	5,248	third proportional.
Mult. by $(1+m)\ w =$	.313	
First approx., $p^1=$..	1,643	lb. on the sq. in.
Intended resultant stress, $s =$	8,000	
Multiply by $s - p^1 =$	6,357	
Second approx. $q^{11\,2}=$	50,836,000	
" " $q^{11} =$	7,131	lb. on the sq. in.
First " $q^1 =$	7,200	
$q^1 - q^{11} =$	$-\,69$	

Second approximation to required diameter:

$$d^{11} = 17.15 \left\{ 1 \times \frac{69}{3 \times 7,200} \right\} = 17.21 \text{ in.}$$

ROLLING MILL GEARING.

The heaviest cog-wheels in the world—always excepting Mr. Isherwood's screw steamships—are to be found in iron rolling mills. Nothing at all resembling this gear is to be discovered in flour or cotton mills, or in any other situation on land where steam power is employed. Spur-wheels 18 ft. to 25 ft. in diameter, 24 in. wide on the face, and 8 in. or 9 in. pitch, are not uncommon; while pitches of 6 in. and widths of 18 in. and 20 in. may be met with in almost any little rolling mill we can enter. The quantity of gearing employed in driving an ordinary rail or forge train is even more remarkable than its dimensions. First, we have a tremendous spur-wheel on the engine shaft, working into a pinion on the fly-wheel shaft, which gears again into a spur-wheel, on the shaft of which is a square end to take the coupling-box and breaking-spindle to the rolls. We have in this arrangement three spur-wheels and six bearings, all of the largest and heaviest class; and this, be it observed, is rather a simple mill than otherwise. When a hammer, a shears and a second train have to be driven, we generally find as much gearing as would fill a good-sized modern dwelling-house, running at a high velocity, for the most part badly put to work, and therefore noisy and liable to accident. It is not too much to say, in fine, that at least one-half of the whole power developed is expended in keeping this gearing in motion; while its first cost represents one-half the capital invested in the plant of any iron mill.

It is worth while, under such circumstances, to consider whether gearing may or may not be dispensed with; and whether we can or cannot improve upon arrangements admittedly objectionable if tested by comparison with other mills. In dealing with the subject, we must first ascertain why gearing is used at all. This point is soon settled. The velocity at which ordinary trains run varies between 40 revolutions per minute for sheet mills and 100 revolutions per minute for bar or rail mills. Higher and lower velocities are met with, no doubt, but the two which we have named are those most usually adopted, and all that we shall say on this subject just now, will be sufficiently illustrated by cases afforded by those two speeds. Now the work to done in rolling iron is excessively variable, and it is therefore necessary to employ great fly-wheel power, in order to store up force at one time sufficient to carry the bar, rail or sheet through the rolls at another. Without going into mathematics, we may state here that the force afforded by any fly-wheel for overcoming the resistance offered to the rolls of a train varies as the square of the number of revolutions, the weights being the same. Thus, a fly running at 80 revolutions per minute would be practically four times as efficient as one similar in all respects and running at 40 revolutions. Therefore it has come to be looked on as an axiom by rolling mill engineers, that the fly-wheel cannot be run too fast. As a consequence, in old works we always find it put on a second-motion shaft, never on the engine shaft. In the endeavor to obtain high fly-wheel speed we find the first cause for the introduction of gearing in rolling mills.

The second reason lies in the fact that until a few years back, slow moving engines of great size were alone employed to drive sheet and rail trains. These engines had a long stroke, and ran at but eighteen or twenty revolutions per minute. This being too slow for any but blooming rolls, gearing became a necessity. The enormous dimensions usually imparted to rolling mill gearing is explained by the fact that it is exposed to many shocks and jerks which are peculiar to the work which it performs, and that for the most part it is roughly and cheaply made, and carelessly put together. We have, we believe, given in the foregoing paragraphs every valid reason which can be alleged in favor of the use of clumsy, heavy, costly gearing in rolling mills. It remains to be seen whether these reasons are or are not incontrovertible.

Taking the last phase of the question first, we may state that during the last few years better materials, better proportions, and superior workmanship have been introduced by many makers, such as Claridge, North & Co., and others, with a view to keep down the weight of mill gearing, and with much success, especially in Staffordshire; and it is beyond question that still more may be done in this direction. But it is quite in another way that we must look for radical improvement. We must begin at the fountain head, and instead of heavy, lumbering, slow working engines, resort to the use of machines making a fair number of revolutions without an excessive piston speed. A good deal has already been done in this direction, we are happy to say. At Woolwich arsenal the splendid bar mill is driven direct at some 60 revolutions per minute by a horizontal engine. In this case power is stored up in one of the finest fly-wheels in England, weighing 50 tons. The sheet train of the Warrington Wire Iron Co. is driven direct by an engine fitted with a 60-ton fly-wheel. These great weights are rendered necessary by the comparatively slow speed of the trains. When velocities of 100 revolutions are attained a 20-ton wheel will answer every purpose. As an illustration we may cite the Pendleton works, near Manchester, where a 16-in. rail mill is driven direct at 100 revolutions per minute, by a horizontal engine with a 26 in. cylinder and 4 ft. 6 in. stroke. This engine has been running constantly for the last fifteen years, with few or no repairs. The advantage of this system cannot be over-estimated. The cost of a great mass of heavy gearing is saved; the price of the engine is not nearly that of a larger and slower running machine; the chances of breakdowns are reduced to a minimum; and the expense of repairs, wear and tear, and lubrication is obviously very greatly diminished.

When, as in sheet mills, the rolls run too slowly to permit the engine to be coupled direct to them with advantage, the best plan will still be to use a small engine, running at some 70 or 80 revolutions per minute, and carrying on its shaft a spur-pinion gearing into a spur-wheel on a second-motion shaft driving the rolls direct; we thus retain a high velocity in the fly-wheel and a cheap engine, although some of the disadvantages connected with the use of gearing unavoidably remain.

The gearing at present usually employed in reversing mills consists of no fewer than five huge spur-wheels and pinions, besides the clutch-boxes. The entire arrangement is simply a barbarous relic of the past. Reversing mills should be driven by small, high-speed coupled engines, without fly-wheels, and fitted with a link motion. The first cost is not greater than that of the normal arrangement, while the waste of power and the chances of derangement are greatly reduced. Those who wish to realize what can be done in this direction, should see for themselves engines and mills designed by Mr. Ramsbottom for Crewe, and others manufactured by Messrs. Tennant, Walker & Co., of Leeds, for America.

The above is from the "Engineer." There are many mills in this country to which these criticisms apply. But the greater number of our *rail* mills have engines coupled directly to the trains—vertical engines, too, which take up the least room. And for work no heavier than rails our three high mill is a vast improvement on the reversing mill. Indeed, with proper lifting gear, it is probably better for the heaviest work, such as 15 in. beams. In some of the new English rail mills, two or even four trains are connected to a single engine by no end of cog-wheels.

We can copy the English practice with advantage in many cases; but in the matter of rail mills, our neighbors should study our practice, for instance at Reading, where they would see three 23 inch 3-high trains, driven each by its own direct vertical engine, at 60 to 80 revolutions; at Harrisburg, where a 40 in. by 60 in. direct vertical engine drives a 24 in. 3-high *steel* train, four rolls long, at 60 revolutions; and at Johnstown, where a similar engine, with a 60 ton fly-weel, drives, direct, a 21 in. puddle train five rolls long, and two squeezers.

THE BED OF THE ATLANTIC.—It has for some time been a question in the learned societies of England, as to the nature of a gelatinous substance formed at the bottom of the Atlantic, specimens of which have been brought up by sounding apparatus. Prof. Huxley has given it the name Bathybius. By some it is considered a gigantic Protozoön, which covers a vast area, miles in extent, forming a living mass over it. It would thus be an agglomeration of microscopic animalcules, probably possessing, like plants, the power of subsisting upon inorganic matter.

FAIRLIE'S LOCOMOTIVE CAR.

This is a long, eight-wheeled passenger car, resting at one end on an ordinary truck, and at the other on a locomotive truck. It is designed to run on rails laid upon common highways or upon ordinary railways. We compile the following description from "Engineering": The leading bogie, or truck, which has coupled wheels 4 ft. in diameter, is fitted with steam cylinders, and carries an upright steam boiler, and a platform for the driver and plenty of fuel space. The cylinders are inside, and are 8 in. in diameter, with 12 in. stroke. The boiler, which is of the "Field" class, stands on the platform of the truck midway between the two axles; the shell is continued downwards for about 16 in. below the fire-grate, so as to form an ashpit. The carrier frame is provided with a strap which completely encircles the base of the boiler, this strap being fitted with brass rubbing pieces on the inner side, so that the base of the boiler—which really forms a large bogie pin—can revolve freely within it to the extent of a quarter of a circle. At the hind end the carrier frame rests on the center of the trailing bogie, this latter being arranged so that it can swivel freely, and being provided with four ordinary carrying wheels, 2 ft. 6 in. in diameter. The carrier frame is made of four longitudinal frames, with cross frames and diagonals, the longitudinal frames being strengthened by truss rods, and the inside frames being connected for a portion of their length by plates at the top and bottom, so as to form a long shallow tank about 4 ft. wide by 12 in. deep. Under this arrangement the tank serves to materially stiffen the carrier frame, and at the same time the weight of the water is distributed over a considerable length of the latter.

The exhaust steam is led into the tank and made to traverse the whole length of the latter before being conducted to the chimney. In passing over the surface of the water a portion of the steam is, of course, condensed, whilst the remainder is discharged into the chimney without any objectionable noise. The chimney passes over the whole length of the carriage to the rear end; and we may here remark, by the way, that from experiments during the construction of some locomotives on the Northern Railway of France, having chimneys somewhat similarly arranged, it was proved that the action of the steam jet was fully as effective in chimneys so placed, as in those in the ordinary vertical position (!). Mr. Fairlie, however, places the chimneys of his steam carriages vertical, as usual in all cases, except when they are intended for working on a line laid along an ordinary road.

On the carrier platform is placed a carriage body, this latter being perfectly distinct from the carrier frame itself, and being merely a covering for the passengers, so that it can at any time be readily removed for repairs, and another bolted on in its stead. Instead, however, of removing the carriage body from the carrier frame, the latter may be readily detached from the leading bogie by simply taking out the bolts of the strap which embraces the base of the boiler, and the leading bogie—which may, in fact, be termed the engine—can then be attached to another carrier frame. When the leading bogie is detached, the front end of the carrier frame is supported on a pair of wheels which, by means of screws and a hand wheel with suitable gearing, can be lowered down so as to bear on the rails when desired. The ready means which are afforded for the detachment or separation of the various parts of Mr. Fairlie's steam carriage forms an important feature in his system, and one which will very greatly facilitate the execution of repairs. Thus, on a line where these carriages are employed, it will never be necessary to stop the running of an entire carriage to execute the repairs of one part, the replacement of a damaged engine, or carrier frame, by a duplicate kept in reserve, being the work of less than half an hour.

The construction of the carriage body is varied, by Mr. Fairlie, according to the nature of the traffic. For a light railway, constructed on a common road, and unprovided with regular stopping stations, (the carriage being intended to stop to pick up passengers like an ordinary omnibus,) the body is divided into two parts, for first-class (to seat 30) and second-class (to seat 50) respectively, the entrance to the former being in the rear of the vehicle, and that to the latter near the middle of the length of the carriage. A longitudinal gang-way runs the whole length. In both cases the steps are so arranged that passengers can readily mount into the vehicle from the road level. When the steam carriage is intended for running on a line provided with regular stations, Mr. Fairlie constructs the body with compartments and side doors in the ordinary way. Thus arranged the carriage is well adapted for working passenger traffic on branch lines or for metropolitan traffic.

In the construction of the vehicle, steel is used instead of iron in all parts where its employment is advantageous, and care has been taken, by properly proportioning the various details, to avoid all unnecessary weight. The calculated weight of the whole vehicle, without passengers, but with fuel and water for a 40 mile run, is under fourteen tons; whilst with 80 passengers the weight would only be 20 tons, of which rather more than half would rest on the wheels of the steam bogie. It will thus be seen that the ratio of unpaying to paying load is, when the carriage is fully loaded, only about $2\frac{1}{3}$ to 1, while, as about 55 per cent of the total weight is available for adhesion, the carriage would be readily able to mount gradients of 1 in 16, if sufficient cylinder power was provided. In the case of a steam carriage, designed for running on gradients 1 in 35 or 1 in 40, the following are the calculations of adhesion, etc.

On an incline of 1 in 35, the resistance due to gravity would be 64 lb. per ton; and if we take the frictional and other resistances, exclusive of gravity, at 20 lb. per ton —an ample allowance—we shall have the total resistances as follows:

Gravity, 20 tons, at 64 lb. per ton,		=	1,280
Friction, etc.,	20 "	=	400
Total, ...			1,680

Again, as about 55 per cent of the total weight rests on the wheels of the leading bogie, we should have

$$\frac{2240\times20\times55}{100}=24{,}640 \text{ lb.}$$

available for adhesion, an amount which, on an incline of 1 in 35, would be reduced to $24{,}640-\frac{24640}{35}=24{,}640-704=23{,}936$ lb.; and dividing 1,680 lb., the total resistance, by this number, we get $\frac{1680}{23936}=\frac{1}{14\ 8}$ as the co-efficient of adhesion required. In other words, so long as the adhesion exceeded, say $\frac{1}{14}$th of the weight on the driving wheels, the carriage would ascend an incline of 1 in 35.

On the other hand it will be found also, that the cylinder power is sufficient for taking the carriage up such an incline, the boiler being worked at a pressure of, say, 140 lb. per sq. in. Thus with 8 in. cylinders, 12 in. stroke, and 4 ft. wheels, the tractive force exerted for each pound of effective pressure on the pistons is 16 lb. To overcome the resistances amounting to 1,680 lb., as already calculated, the mean effective cylinder pressure would have to be 105 lb. per sq. in.

On a level road the total resistance of a steam carriage such as we are describing, running at a speed of 40 miles per hour, should not exceed 20 lb. per ton, or, taking the weight at 20 tons, 400 lb. in all. To overcome this resistance would require a mean effective pressure of 25 lb. per sq. in. on the pistons, and the power exerted would be $\frac{400\times5280\times40}{60\times33000}=42.6$ horse-power. On an incline of 1 in 100 the total resistance would be about $42\frac{1}{2}$ lb. per ton, or 850 lb. in all, corresponding to an effective pressure on the pistons of 53,125 lb. per sq. in., and to the development of 95.8, or say 96 horse-power at the same speed.

On a line with moderate gradients, say up to 1 in 60, and at speeds varying from 25 to 40 miles per hour, such a steam carriage as that we have described should be run with a consumption of about 6 lb. of coal per mile, and with a correspondingly small consumption of oil, tallow, etc. The expense for wages also would be very small, as the engine could be readily managed by one man, while the guard would have charge of the brake, and would be able to collect fares. Brake-blocks are to be applied to all the wheels; and the arrangement of brake-gear is such that the brakes can be applied either by the guard or driver independently.

Although the total wheel base of the carriage is 57 ft., yet the actual wheel base which has to be considered when estimating the capability of the vehicle for traversing curves, is that of each bogie, or 6 ft. only. With this base the carriage can be safely run round curves of two chains radius, at moderate speeds, while at a slow speed a curve of 35 ft. radius may be traversed. Thus, by placing circular curves of 35 or 40 feet radius at the terminal stations, the carriages can be run round, and the expense of turntables avoided.

We have hitherto spoken of Mr. Fairlie's steam carriage as running by itself only; but it will be evident from what we have said that it possesses ample power to draw, under ordinary circumstances, another carriage behind it. In the case of a railway laid on a public road, such speeds as 40 miles per hour would, of course, never be attempted, a speed of twelve or fifteen miles per hour being more nearly the maximum; and in such instances the boiler would possess ample power to supply the cylinders with steam at the full pressure admitted for, say three-fourths the stroke, and ample tractive power would thus be afforded for drawing another carriage, or trucks loaded with goods. Altogether Mr. Fairlie's plans are exceedingly well considered, and we feel sure that at the present moment — when light railways are the subject of much attention—they will be regarded with great interest.

INDEPENDENT TUBULAR BOILERS.

From the "Practical Mechanic's Journal."

The Seguin tube boiler applied to the early locomotive by the Stephenson's, and proved capable of such rapid and efficient generation of steam, gave almost at once an impulse to the use of tubular boilers of one sort or other for land and fixed engine use, which, however, has not been followed out, nor has progressed as steadily as might have been wished.

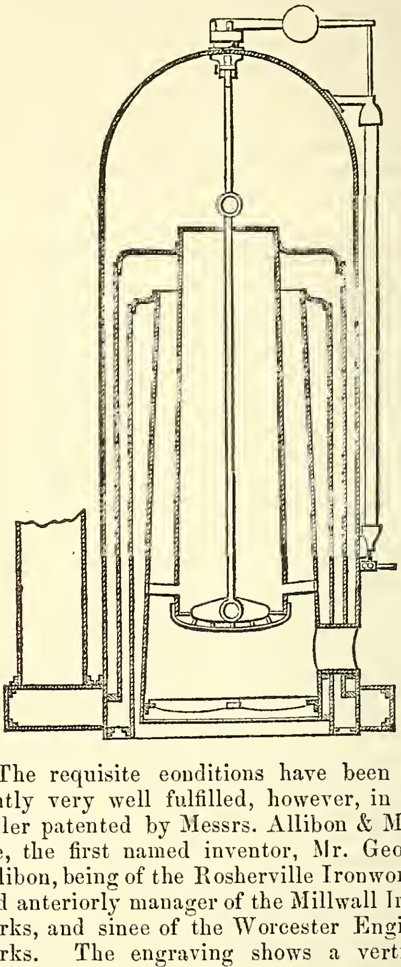
As long ago as about 1836 Messrs. Mather, Dickson & Co., of Liverpool, were amongst the first to adapt to fixed engines the locomotive boiler, pure and simple, but enlarged, and from the designs of Mr. John Grantham, C. E., the very large boilers, for that day, were constructed and fixed at Edgehill Station, for the supply of high-pressure steam to the fixed engines also constructed by them for working by rope traction the incline in the tunnel between there and Lime street. These boilers worked with economy and satisfaction for several years; we believe no objection was ever made to them but that of their considerable first cost. Many years ago, also, Messrs. Rennie employed for one or more engines in their works in London, a vertical boiler, consisting of a simple cylindric external shell, a drum fire-box inside, carrying above it a large number of vertical tubes, the gases from the whole of which were gathered into one central flue, which passed off directly from the top of the boiler. The water surface was necessarily below the top tube plate, and so a small length of the upper and cooler end of the tubes, and of the top tube plate, were exposed to contact with steam in place of water. This boiler, we were ourselves assured by the late Mr. George Rennie while examining it, had then for some time continued to give them steam at high pressure, with a consumption of mixed coal and coke equivalent to not more than $2\frac{1}{2}$ lbs. per hour per indicated horse-power.

This form of fixed tube boiler, of great simplicity, and as great cheapness as any tube boiler perhaps is susceptible of, had even to a rather greater degree than the horizontal-tubed locomotive boiler the advantage of permitting easy repairs. The misfortune of all fixed tube boilers, which, for land work, are required as one of their primary conditions to be worked for long periods and perhaps without a moment's cessation, is, that the surfaces of the tubes, whether these are exposed exteriorly or interiorly to the water contact, coat and fur over with earthy matter, deposited or collected, and concreted from the water at a rate that is injurious to them, though less so with boilers exposing broad, flat, or curved surfaces to the water. The small tube is practically at all temperatures so nearly the same diameter that scale formed does not easily crack off spontaneously, while it has a much better chance of doing so from broad surfaces, which are continually changing their shape with variations of pressure, and their dimensions with difference of temperature. Mere length in tube does not seem capable of letting it clear itself thus of scale. Besides hard accretional scale, most natural water deposits more or less loose mud or sediment. Now, the horizontal locomotive tube form of boiler may be so made for fixed or land use, that most of this shall keep away and deposit clear of the tubes. This advantage, however, is not secured by the simple vertical form of tube boiler above described, as constructed by Messrs. Rennie; for the loose sediment, as well as any that may detach itself from the tubes, falls down and lies amongst the tubes, on the lower tube plate, and gradually passes thence by ebullition and currents in the boiling water, down to the bottom of the water wards of the fire-box; and it is at all times an unhappy arrangement when the sediment tends to deposit finally about some of the hottest parts of the boiler plates.

Another form of fixed tubular boiler, known as Inglis' in the north of England, and, we believe, the subject of a patent, was in use at the Elswick Works, near Newcastle, about 1863, and when we saw it, appeared to have been working in a very satisfactory, and we learned, as we should have expected, in an economical manner. This boilers consists of two dome-topped cylindrical shells, of unequal diameter and height, connected together, above and below, by two cylindrical water flues, big enough for a middle-sized man to squeeze through. The larger cylinder contains the fire-box, and a smoke flue, rectangular in section, leading from the fire-box through the walls of both cylindrical shells, and into a cylindrical tube chamber in the center of the smaller cylinder, from whence a fasciculus of vertical tubes descends to the lower end or tube plate of the same cylinder. The whole boiler sits in brickwork, the ash-pit in front of the fire door being covered with a perforated cast-iron foot-plate.

Now most of the important conditions for tubular boilers are found here combined; every part, inside and outside, is as readily come-at-able as need be. There is ample circulation of the water, and a large surface both of fire-boxes and of tubes can be readily secured and well applied; moreover except as to the tubes themselves, scale has as a good chance of detaching itself here as in any other boiler of broad plates; there is ample room for the deposit of sediment, and by mud-hole doors can be made, so easily and so accessibly, that it can be periodically cleared out, if not removed even more frequently by mud cocks. It is also all pretty simple boiler-makers' work, both to make and to repair, and changes of dimension from hot to cold act systematically upon it, and tend little to rack its frame. It is, however, not a cheap boiler. When employed for uninterrupted service, the best mode of feeding it with water—and, indeed, this applies to every form of fixed tubular or lamellar boiler—would be to pass the feed water into a heating vessel of cylindrical form, placed in the horizontal flue, and so arranged that the sediment deposited in that could not enter the boiler, and should be easily removed from the vessel while the boiler continued at work.

A decided advance could be made thus upon the construction of multispaced fixed boilers, if we can abandon or reduce to the smallest extent tubes, and construct the boiler upon the lamellar principle instead; for then we shall substitute broad surfaces, which tend to keep clear from scale (under usual conditions), for small diametered tubes, which tend to clothe themselves with scale. This has been attempted in a multitude of forms—with flat water wards of one shape or another, as in Mr. Lamb's marine boilers; but such surfaces do not readily admit of the requisite strength for high-pressure steam, however admirably they may work under the conditions and moderate pressure of marine boilers.



The requisite conditions have been recently very well fulfilled, however, in the boiler patented by Messrs. Allibon & Manbre, the first named inventor, Mr. George Allibon, being of the Rosherville Ironworks, and anteriorly manager of the Millwall Ironworks, and since of the Worcester Engine-works. The engraving shows a vertical section of this boiler, the construction of which is so simple, that it will be understood almost without description by any one acquainted practically with boiler work. It consists of a vertical cylindrical shell (which may be of greater or less height to suit circumstances), containing four other shells nearly cylindrical, and so united that each alternate annular space is filled with water, while the other alternate ones afford, in a direction of movement up or down, passage for the gases of combustion of the fire, the fire-box for which is in the bottom of the cylindrical and internal shell, on their way to the chimney.

The advantages secured by this boiler are pretty evident; it is very simple in workmanship, and admits of great strength. Two of the cylindrical internal shells are exposed to compression on their convex surfaces by the steam or water, but these can be easily and well stayed up to those against the interior or concave surfaces of which the pressure acts. The parts are easily pulled out one from the other for examination or repair, and with extremely little boiler work, or unmaking and remaking of joints. There will be but little fast scale, but the loose deposits will require to be passed off at intervals with regularity. In our own judgment the four short tubes of water communication between the central cylinder would be best put somewhat higher up, and a sediment box of parallel contour with the rounded bottom of this cylinder placed within it, and suspended from above. If judiciously placed, and the feed water (from an external heater always) properly introduced and led first into that suspended vessel, we think almost all sediment would take place therein, and all the rest of the boiler remain nearly free. Two conjugate boilers of this sort obviously might be made, and fired from one fire-box in one of them, something as in Inglis' boiler, and probably with advantage as to consumption of fuel. This form of boiler might be made very suitably applicable to the use of liquid fuel, assuming, what has not yet been properly done, that that fuel is burnt as vapor, mixed with its equivalent of atmospheric air previously heated to a sufficient temperature by the waste or other heat.

We entertain but little doubt that these boilers will prove safe, economical in work, and, at the very least, as much so in repair, as any known form of multispaced boiler. In respect to its central cylinder this boiler bears some little similitude to Mr. Thompson's "pot boiler," exhibited in 1867 at Paris; none whatever, in its general design, which is greatly superior to that of the pot boiler.

Large Gas Holder.—Mr. Thomas F. Rowland, of New York, has built, for the works in Twentieth street, New York, a gas holder 170 ft. diameter, by 70 ft. high, in two 35 ft. sections.

TECHNICAL EDUCATION IN FRANCE.

We quote from "The Engineer" a translation of the scientific syllabus of the Paris Conservatoire. Scientific lectures are read by eminent *savants*, not only at the Conservatoire, but at the Sorbonne, Collège de France, Jardin des Plantes, &c., and this practice constitutes a most important feature in the French educational system.* In France secular tuition is either very cheap or entirely gratuitous, without any restriction as to age, sex, nationality, or religious opinions of the students; in fact, no questions are asked as the student enters the lecture-room, provided he behave decently.

CONSERVATOIRE IMPERIAL DES ARTS ET METIERS — PUBLIC AND GRATUITOUS COURSES OF LECTURES ON SCIENCE APPLIED TO THE USEFUL ARTS. 1868–1869.

Geometry, Practical.—M. Baron Ch. Dupin, Professor; M. Lausedet, Assistant. Programme: Theory of the principal curves employed in the drawing and construction of machinery; diagrams of parts serving to transform motion; toothed wheels; cams; eccentrics; articulations; escapements; counters; registering instruments.

Geometry, Descriptive.—M. de la Gournerie, Professor. Programme: Rules of linear perspective, and geometric constructions referring to it; effects of perspective; instruments of perspective; curved pictures; perspective of bas-reliefs; stage scenery; rapid perspective.

Practical Mechanics.—M. Tresca, Professor.—Programme: General principles of mechanics; definitions; effect of forces; mechanical work; principle of the conservation of work; means of developing and employing mechanical work; passive resistances; uses of machinery; composition of engines; description and theory of machinery used in industry.

Civil Constructions.—M. E. Trélat, Professor.—Programme: Materials, classified according to their uses, and to the æsthetic expression that they afford; theory of the elements of construction; foundations; vertical and horizontal walls; roofs.

Practical Physics.—M. E. Becquerel, Professor. Programme: Fundamental laws of general physics; the applications of heat; formation of vapors; use of their elastic force; sources of heat; warming and ventilation; molecular action; general laws of acoustics; fundamental laws of light; sources of light; construction of optical instruments.

Practical Chemistry.—M. E. Peligot, Professor. Programme: First part of the course, general phenomena of combination and decomposition; equivalents, nomenclature and symbols; natural history of simple non-metallic bodies, and of their principal combinations; air; water; mineral acids; ammonia; useful metals.

Manufacturing Chemistry.—M. Payen, Professor. Programme: Composition of vegetable matter, cellulose, preservation of timber and grains; starch, dextrine, glucose, gluten, Italian pastes;

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* See Van Nostrand's Magazine, No. 2, page 116.

food; hygiene; sugar manufactures; alcohol, wine, beer, cider; paper; soap, gelatine; hydro-carbons, petroleum, lighting and warming gas.

Agricultural Chemistry.—M. Boussingault, Professor. Programme: Experimental demonstration of the process of testing and analyzing substances produced or utilized by agriculture; means of detecting adulteration.

Agriculture.—M. Moll, Professor. Programme: Exposition of the special rules of agricultural zootechnia; breeding, rearing, and employing horned cattle, pigs, poultry, horses.

Rural Works.—M. Mangon, Professor. Programme: Agricultural hydrology; drainage; manufacture of drain pipes; cleaning drains; desiccation (drainage); polders; colmatage (manure irrigation); ponds; fish culture; irrigation with pure or muddy water; legislation on water; plantation of forests; grass; sand-hills; forest industry.

Spinning and Weaving.—M. Alcan, Professor. Programme: First process in hand and machine weaving; plain, curled, and figured webs; openwork and stocking web; cleaning and mechanical preparations; sewing, embroidery, and ornament machines.

Dyeing and Printing.—These lectures are not commenced yet.

Political Economy and Industrial (Factories) Legislation.—M. Wolowski, Professor. Programme: Division of labor and co-operation; barter; money; law of germinal an xi. (of the French republic); trust money (credit); exchange; contractors and workmen; strikes; trade unions; association.

Industrial Economy and Statistics.—M. J. Burat, Professor. Programme: On production; on the forces employed by production; natural forces, work, capital; on the principles and economic laws regulating the industry of agriculture, manufactures, and trades; on the institutions which facilitate production; weights and measures, bills of exchange, and means of credit; means of communication, roads, canals, railways.

PRESERVING TIMBER.

An abstract of a paper read at the meeting of the Chemical Section of the Philosophical Society of Glasgow, by Mr. P. M. Moir.

This paper was specially written to explain the methods that have been and are now in use for the preservation of timber from decay by disease and exposure to the atmosphere, or destruction by marine worms and insects.

Timber when exposed to the action of the atmosphere is soon acted on by damp. This is especially noticeable in all timber fixed in the ground. The action commences at the parts immediately above the surface of the ground, where the fibrous portions of the wood are softened by the moisture, mould and decay being produced. These are indicative of a sort of slow combustion which is set up by the alternations of wet and dry. This kind of wasting away is termed wet rot. Another and very destructive form of decay is that which is known as dry rot. This goes on most rapidly where there is no circulation of air. It is believed by some persons to be caused by parasites; but by others it is believed that the parasites only appear after the decomposition has set in, and that they appear and live to consume the materials which by their accumulation might render the earth and air unsuited to the essential conditions of life and health. There is some probability that dry rot is a result of the felling of timber while it is full of sap, that is, between the end of spring and the beginning of autumn. Another familiar form of disease is that which is caused by the Termite or white ant. This creature's operations prove very destructive in India, Ceylon, Brazil, and most tropical countries. Its attacks are most ravenous on all wood buildings, railway sleepers, and bridges, even though the constructive material be lignum-vitæ, one of the hardest and most durable of woods.

When timber is used in marine structures the destructive agents are greater enemies than decay by dry or wet rot. There are two of them which are the best known among salt water destructive agents, and are very ruinous to all wood erections which are unprotected from their ravages either chemically or mechanically. They are the *Teredo navalis*, or ship-worm, and the *Limnoria terebrans*. The teredo is a long worm-shaped creature which perforates timber generally in the direction of the grain, but sometimes across the grain with many windings. When a knot is met with, or the shell of another teredo, the creature accommodates itself to circumstances by bending from its original course. In a fir pile taken from the old pier of Southend a worm was found two feet long and three-quarters of an inch in diameter. Some have been seen three and even four feet long, and one inch in diameter. The teredo grows very rapidly, and its ravages are often very terrible on ships, piles, &c. The teredo is not nearly so prevalent on the Scottish coasts as in the South of England and on the coasts of France and Holland where unprotected timber is readily destroyed.

The *Limnoria terebrans* is very abundant around the British shores. Its ravages were first particularly observed in the year 1810, by the late Mr. Robert Stevenson, engineer of the Bell-Rock Lighthouse. The limnoria very much resembles a wood-louse, and is about 1-6 inch in length. It is gregarious, and in situations favorable for the exercise of its habits it soon produces great effects on the wood to which it attaches itself. By boring in all directions it so disintegrates the wood as to allow the sea to wash away its surface, and thus layer after layer of the wood is riddled by the borer, and then abraded by the sea until the whole piece of timber attached is completely destroyed.

Various opinions have been entertained regarding the mode in which the limnoria perforates and destroys timber, but the opinion expressed by Dr Coldstream after very careful observation seems to be the most worthy of credence. He states that the animal effects its work by the use of its mandibles, and it seems that it is necessary that the hole should be filled with salt water. The distance bored is from one to two inches long, and as the hole increases in size the animal leaves its old workings and begins new ones.

All kinds of timber in the unprepared state, except greenheart, are readily devoured by the limnoria, if used in harbor works not exposed to the influence of fresh or river water. Greenheart is not molested by the animal at all, but every other kind of wood is attacked immediately that it is put into the sea, whether afloat or fixed, but more readily if fixed. The boring is generally limited to that portion which is between two-thirds flood and the bed of the sea or estuary. The rate at which the limnoria bores into wood in pure salt water is said to be about one inch in a twelve-month; but instances have occurred in which the destruction has been much more rapid. At Greenock, for instance, a pile twelve inches square was eaten through in seven years. The limnoria cannot live in fresh water, hence it is not found doing any damage in the Clyde higher than Port-Glasgow.

Greenheart timber in its natural state is the only wood now in use for harbor works that is proof against the attacks of marine creatures, and those of the white ant in tropical countries. There are two reasons why it enjoys this immunity from attack: first, there is its great hardness; and, secondly, there is the presence of a large quantity of essential oil. It is a very hard and durable wood, weighing about 75 lbs. to the cubic foot, and having a specific gravity of 1.089, so that it is a little heavier than water. It is brought from Demerara. Great care is required in working it, as it is very liable to split. In sawing it is necessary to have all the logs bound tightly with chains, failing which precaution the log would break up into splinters, and be very apt to injure the men working it.

The author then proceeded to discuss the various mechanical and chemical methods that have been employed to preserve timber from natural decay or from the destruction effected by living creatures. The mechanical methods are wholly employed for marine purposes, and are the oldest in use. One of these consists in covering piles, between high and low-water mark, with flat-headed iron nails, the heads being about one inch in diameter, and the nails being driven in so close that the heads touch, but do not overlap each other. This method is expensive, both on account of the materials employed and the time required in the operation; and besides this it is very inefficient, as the nails readily corrode, and leave room for the attacks of the living enemies. Another plan is to cover the piles or other submerged timbers with sheets of zinc or copper. This also is an efficient means of protection.

For the preservation of wood by means of chemical preparations, although many patents have been taken out, not more than six have been worked commercially. In all cases these patents were obtained for the use of solutions of certain chemical compounds as preservative agents. The names of the patentees and the most valuable compounds employed are shown in the following table:

Kyan - - -	1832	Chloride of mercury.
Margary - -	1837	Sulphate of copper.
Bethell - - -	1838	Creosote or pitch oil.
Bethell - - -	1848	
Burnett - -	1838	Chloride of zinc.
Burnett - -	1840	
Boucherie - -	1839	Pyrolignite of iron.
Boucherie - -	1846	Sulphate of copper.
Payne - - -	1841	Sulphate of iron.
Payne - - -	1846	Carbonate of soda.

The methods employed practically in working these patents were three in number, namely, steeping, vital suction, and pressing in close vessels. Kyan and Margary employed the first-mentioned method; Boucherie employed the second; and Payne, Burnett and Bethell employed the third, which was also latterly adopted by Boucherie. The first and third methods required that the timber should be seasoned and free from sap.

The author described each patented process at some length, mentioning how it is carried out, the advantages and disadvantages in each case, and the conditions under which it has any practical benefit. In no case did the evidence regarding the value of the process seem to equal that in favor of the creosoting process patented by Bethell, at all events if the timber is to be exposed to the weather or to be used in structural works which are subjected to the action of either fresh water or salt water.

Kyanising, or injecting corrosive sublimate (chloride of mercury) into timber, is very expensive if properly done; and besides this there is the fact that it is practically useless, inasmuch as it has been found that kyanised piles, after three years' immersion in the sea, did not contain a trace of the preservative compound.

Sulphate of copper, first suggested as a preservative agent by Margary, and afterwards employed largely by Boucherie, may be used to prevent dry rot in timber; but for piers, bridges, railway sleepers, and other structures which are exposed to the action of water, it has no practical value, as the water dissolves out the salt with great rapidity. Timber prepared with this salt, and used for marine purposes, is as readily destroyed by the teredo and the limnoria as unprepared timber.

In Payne's process solution of sulphate of iron is first absorbed into the wood, and afterwards carbonate of soda. Double decomposition ensues, and the practical result is the formation of oxide of iron, the deposition of which renders wood brittle, and does not prevent the attacks of either of the animals just named.

Of Sir William Burnett's chloride of zinc process the author could say nothing from personal experience. The essential part of the chemical action of the compound is the formation of an insoluble coagulum with the albumen of the wood. It is claimed for the Burnett process that it renders wood proof against the attacks of the white ants in India; and wood for in-door purposes is permanently improved by it.

Bethell's patent process for preserving timber by the use of creosote pitch oil is the only one which really accomplishes the object aimed at, although many patents for the use of oleaginous substances had been secured prior to the year 1838, with the same object in view. Creosote acts very powerfully in coagulating the albumen contained in the cells of the wood, and besides this it effectually preserves the fiber of the timber, and hence its value over all other so-called preservative agents.

The apparatus required in the creosoting process consists of an injecting cylinder, generally about six feet in diameter, and varying from 30 feet to 70 feet long, together with exhaust and pressure pumps, an oil tank, and the requisite piping connexions. It is not unusul to have both ends of the cylinders open, so that the timber may be entered at one end and removed at the other with the greatest facility, and to have them fitted with air-tight iron doors, which are removable at pleasure. When the cylinder is charged with timber, and the door or doors properly secured, the air is extracted by the air pump, both from the interior of the cylinder and from the pores of the wood. A vacuum being produced in the cylinder, the oil, which has been heated in the tank by steam pipes to a temperature of about 120° fahr., is allowed to rush in, and when the cylinder is full, the inlet pipe is shut and the pressure pumps are started to force the oil into the wood, the pressure being maintained at from 150 lbs. to 200 lbs. on the square inch until the wood has absorbed the required quantity of oil, which is learned by reference to an index gauge. For land purposes the amount of oil recommended is eight lbs. to the cubic foot of wood, and for marine purposes from 10 to 12 lbs. per cubic foot. In France, Belgium and Holland, the quantity used varies from 16 lbs. to 26 lbs. per cubic foot when the timber is intended for marine works. Beech wood has absorbed as much as 31 lbs. of oil per cubic foot, and when used for railway platforms or harbor works, it is doubtless the cheapest and most durable material that can be used.

Creosote (or pitch oil, as it is more commonly called in Scotland) is obtained in the distillation of coal tar, the other ingredients being ammoniacal liquor, crude naphtha, and the residual pitch. The coal tar of Scotch gas works generally yields about 25 per cent of oil which distils over at temperatures ranging from 400° to 700° fahr.; in England, however, the amount is only about 20 per cent. The author estimates the annual yield of pitch oil in Scotland at one million gallons, almost the whole of which is used for creosoting purposes. It is probable that creosote owes its valuable antiseptic property to the presence in it of from five to fourteen per cent of crude carbolic acid, but which could not be used by itself for outdoor purposes, as it is slightly soluble in water.

According to Dr. Letheby, creosote acts as a preservative agent in the following ways:

1st. It coagulates albuminous substances and gives stability to the constituents of the cambium and cellulose of the young wood.

2d. It absorbs and appropriates the oxygen which is within the pores of the wood, and so checks, or rather prevents the eremacausis of the ligneous tissue.

3d. It resinifies within the pores of the wood, and in this way shuts out both air and moisture.

4th. It acts as a positive poison to the lower forms of animal and vegetable life, and so protects the wood from the attacks of fungi, acari, and other parasites.

Since the creosoting process was first introduced in the year 1838 it has been extensively employed in Great Britain and Ireland; in all countries on the continent where creosote oil can be obtained—France, Holland, Belgium, Germany, Spain, Portugal, and Italy; and in India, Cape Colony, Brazil, and other tropical countries, to preserve timber from the attacks of the white ant. Wherever it has been properly carried out it has been completely successful.

Of late, many railway companies have discontinued the use of creosoted sleepers, not from any failure of the process, but from the wear and tear of the sleepers caused by the chairs cutting down into them and gradually rendering them useless. This mechanical injury to the sleepers would be greatly lessened were the base of the chair made broader. According to Mr. Deas, late engineer on the western section of the North British Railway, it will doubtless be less and less the practice of railway companies in this country, under the present financial depression, to creosote or otherwise preserve their sleepers, as the cost of the operation—6d. to 8d. per sleeper—is such a high proportion to the original cost of the sleeper, which is generally from 2s. 2d. to 2s. 6d. for each, while, owing to the cutting-down action of the chairs, the prepared sleeper becomes useless for permanent wear almost as soon as one unprepared.

For harbor works in Scotland the creosoting process has been largely used. At Leith, the west pier, consisting of 1,013 main piles, is entirely constructed of creosoted timber, and the extension of the east pier contains 312 main piles, also creosoted.—These erections were commenced in 1848, and finished in 1853, and at the present time they are as perfectly sound as the first day they were put down. The gates of the new dock now being constructed at that port are made of creosoted pine bound with greenheart timber, the quantity of oil used being ten lbs. per cubic foot. At Glasgow all the wooden wharves, with the exception of the steamboat quay, are constructed of creosoted pine, eight lbs. of oil to the cubic foot. The whole of the wharves at the Kingston Dock are built of creosoted wood, the same quantity of oil being used. At Port-Glasgow and Greenock timber prepared by the Bethell process is largely used, and the same is true of nearly every port in England. Much attention has been given to the creosoting process by the Belgian Government, and so satisfactory have the experiments been that no other process is used by that government. Very full and interesting accounts of the Belgian experiments upon the creosoting process have been prepared by M. L. Crepin, ingénieur des Ponts et Chaussées, especially in "Annales des Travaux Publics de Belgique," vol. xxi., 1864. M. Crepin affirms that wood retains all its former elasticity in the creosoted state, and acquires a density which it did not possess in the unprepared condition. M. A. Forestier, engineer-in-chief for the department of La Vendee, made a very minute and elaborate report for the Paris Exhibition of 1867 on the creosoting process and experiments made with it on timber used in both land and marine works in France; and in that country the process is also largely employed.

HOW STEREOTYPE-PLATES ARE MADE.

From the "American Artisan."

The surface of the types, set up as for printing, is first treated in the same manner as for electrotyping, except that it is oiled instead of being coated with black-lead. This being done, what is technically called a flask, simply a kind of rectangular frame is placed upon the chase. Plaster-of-Paris brought to the suitable consistency with water is then poured into the flask and upon the surface of the type locked up in the chase, and suffered to harden. This being done, the plaster mold thus formed is brought away from the chase, and consequently from the face of the type, by means of screws arranged at the corners of the flask. By this means the surface of the mold is kept intact from injury, which would occur if the movement of the flask in removing the plaster from the projecting faces of the type were irregular, or even very slightly in a lateral direction. When the mold has been completely detached from the face of the type it is fitted into a cast-iron pan, and both pan and mold are sunk to the bottom of a caldron of melted stereotype metal, which is somewhat different from, although closely resembling, ordinary type metal. This caldron is, of course, arranged over a suitable surface. The mold is suffered thus to remain in the molten metal until the heat of the latter has completely dissipated all the moisture of the mold, so that the metal penetrates without blowing into all the interstices of the mold. The mold being lifted from the caldron is filled with the molten metal, which on cooling constitutes the stereotype, requiring only the finishing operations of planing to thickness and the like to fit it for use in printing. These, being substantially the same as in the case of electrotypes, require no further description here. It should be mentioned, however, that previous to being thus finished, the plaster or material that may adhere to the plate must be removed therefrom by thorough washing, facilitated by the active application of a brush.

It is sometimes preferred that the plates should be cast in clay molds, instead of in those formed of plaster, the clay taking a better impression of low space work than the plaster, and having the additional advantage that it does not fill up the faces of the type like the plaster; this advantage obviating all necessity for cleaning the type after forming the mold, as is essential in the other case.

The material of which the clay molds are formed is common kaolin or potter's clay, mingled with powdered soapstone and properly tempered. Previous to use it is wrought and worked up with a solution of gum-arabic, and a little plaster is added.—Being brought to the requisite condition and consistency, it is spread upon the platen of a press, and the impression of the type or other surface is taken in the same way that the impression upon wax is taken in the preliminary part of the process of electrotyping. The clay thus impressed forms the mold that is to be, and is dried either in an oven contrived for the purpose, or by simply placing it upon the top of an ordinary furnace.—When the clay molds have become thoroughly dried, they are placed one over another and surrounded by metallic frames, which not only serve to close their sides, but also to keep them the requisite distance apart. When thus arranged the molten metal is poured into the spaces between, and on cooling forms the stereotype-plates in the same manner as if cast in the separate plaster molds. Plates may be cast more cheaply by the use of the clay-molds than by the others, and for all ordinary purposes the work is just as good. Where fine and sharp impressions are required, however, there is no mode of stereotyping that gives as good results as the plaster method.

As an addenda to the above description of the manner of making stereotypes practiced by Messrs. Lovejoy, Son & Co., we give a brief sketch of another process—the *papier-maché* process—employed in making the plates used in printing the large editions of some of the morning papers of this city, for which the simple forms of type alone would be wholly inadequate.

In carrying out this process a sheet of blotting paper of suitable size is covered on one side with a coating of paste prepared especially for the purpose, and upon this, and carefully smoothed with the hand, is placed a sheet of tissue-paper. This sheet it cut into pieces corresponding in size to the pages to be stereotyped, and each piece is coated on its face or tissue side with finely-powdered French chalk, applied with a soft brush. The surface of the page of type is sparingly coated with salad-oil, and the paper, face downward, is laid upon the surface of the type. This being done, a piece of damp linen is laid upon the back of the paper, and the paper is then beaten down upon the surface and into the type by means of what is known in the trade as a beating-brush, care being taken to bring the brush flatly down upon the paper at each stroke. When the paper has been well beaten into the type in this manner the cloth is removed, a piece of cartridge-paper is pasted upon the back of the paper matrix just formed, and the beating operation is repeated. This being done, the matrix, still upon the type, is subjected to the action of a press, and afterwards suffered to dry somewhat, which ordinarily requires but a few minutes, after which the matrix is gently lifted and separated from the type.

In casting the plate the matrix is fitted in what is termed a mold, and the metal is poured in, and, filling the mold, on cooling forms the plate, which, if all the various operations of the process have been properly carried on, easily separates from the matrix, and by a few finishing touches is rendered fit for use.

This *papier-maché* process has the advantages of cheapness and quickness in making the plates, and the latter are about equal in quality to those made in the clay molds above described. It is found, however, that the beating of the paper upon the type destroys, in time, the hair lines upon the latter, and thus impairs their value. Another objection to this plan lies in the deterioration of the type-metal, which is found to occur, for some unexplained reason, when the metal is cast upon the paper material of the matrix.

COMMUNICATION BETWEEN ENGLAND AND FRANCE.

From "Engineering."

The prospects, engineering and commercial, of a tunnel beneath the Dover straits, the possibility of constructing such a work, and the chances of a profitable issue if it were ever completed, are at last in a fair way of being thoroughly investigated and decided, so far as it is possible for able engineering foresight to decide them. It is at least a satisfaction to know that the idlers who, with scarcely capacity to lay a water main, treat the construction of twenty-five miles of submarine tunnel as a mere trifle, will perforce cease from troubling with their visionary executive and revenue estimates when a sound opinion has been given on the matter. It is but just, however, to all these schemers to admit, that their perseverance has done something to impress the fact that the present means of communication with the Continent are eminently inefficient and unsatisfactory.

It *may* be, for the limits of possibility cannot be set, that the next generation will see the completion of a railway ligature joining France and England, and that the traffic will have increased so enormously as to pay the high dividends which alone could remunerate the venturous capitalists for their precarious investment. But this, as yet, is beyond the province of sober belief; and there is no reason to imagine, as the advocates of the Channel Tunnel would have us imagine, that passengers would travel in millions beneath the bed of the sea, instead of in thousands on its surface, or that, to the popular mind, an hour of mental agony in a tunnel would be welcomed in exchange for sixty minutes' physical discomfort on the surface. Assuming, however, for a moment that such a scheme has been pronounced feasible, and that the twelve millions or so have been raised for the work, England and the Continent would have to wait patiently for, perhaps, a quarter of a century till the tunnel was completed; so that, at least pending the construction of this great undertaking, we must look for some efficient, if only temporary, means for superseding the present miserable accommodation.

Such a plan is offered by Mr. John Fowler, and the other engineers associated with him, in his English and Continental Intercommunication scheme, deposited last Session, and postponed till next year, for the adjustment of preliminary arrangements, and for the further consideration of the project. It is, indeed, no matter for regret that, publicly, the bill will lie dormant till next Session, for the interval will give time for present opposition to be converted in future co-operation, while the agitation of the permanent communication advocates will urge forward the undertaking.

The route chosen for the crossing is from Dover to Audrecelles, which latter port offers far greater advantages than does the coast at Calais. A shorter course—only 23 miles from dock to dock—deeper water, an absence of shifting sand-banks, and a complete protection from the easterly and north-easterly winds under the lee of Cape Gris-nez, whose lighthouse would direct the course, are among the obvious advantages of the new proposed route. The construction of a few miles of railway from Audrecelles to Wimereux, will save the journey from Calais to the latter station, and shorten the distance to Paris by fourteen miles, although of course travelers to Brussels and towards the north would suffer this disadvantage now incurred by those who have Paris for their destination. As the former class of travelers are, if anything, a little more numerous than the latter, it follows that the traffic of the railway would be increased by the change of landing places, even if the increased facilities of crossing did not stimulate travel. But of this there can be no doubt, although not in the extravagant degree claimed by the tunnel advocates, who must look forward to an unceasing stream of about 250 passengers per hour throughout the year, and an increase of goods' traffic in like degree, to earn a revenue sufficient to pay their dividends and maintenance expenses. This *may* come in the future, created by the submarine link, but so far as we can see there is not a single advantage, claimed for the permanent communication, which is not possessed by the ferry, whilst the latter scheme is, on the other hand, free from the objections fatal to the tunnel.

A moderate capital, easily obtained, would suffice in a short time to establish a perfectly efficient and satisfactory service, that would so far encourage and increase traffic as to produce a revenue representing a large return upon the outlay. The railway companies, both English and Continental, would obtain corresponding advantages with the increasing traffic promoted by the new service, and above all, of far more importance than the new comfort derived by passengers, a satisfactory means of transporting merchandize would be gained, and the delays and injuries to which goods are now constantly exposed would be avoided. Concentrating at Audrecelles from all parts of Europe, the goods' wagons would be transported to the opposite dock to the benefit of the Chatham and Dover and of the South-Eastern Railways, which would necessarily secure through the ferry the bulk of the merchandize that is now exported for the various shipping places of the Continent to the English ports.

Offering all these advantages, we cannot doubt that the English and Continental Intercommunication bill will be freely passed next Session, and that the works will be commenced without delay. The public and the railway companies are alike interested in its completion, and though it *may* have in its turn to give place to a permanent communication, it will have probably a half century of good service without competition, and it would afterwards doubtless be leased, and kept in working order by the tunnel company, in the event of any contingency, to which that great work, after its completion, might in the course of nature be liable.

The Pennsylvania Ironworks, Chester, Pa., have closed a contract with parties in New York for the building of a number of iron steam-colliers for the coasting trade, having a carrying capacity of about 600 tons. They are only the pioneer vessels of a projected large fleet for cheaply transporting coal from the most convenient points of shipment to consumers. Some railway companies are interested in the enterprise.

THE INDICATOR.

PRACTICAL DIRECTIONS FOR APPLYING AND TAKING CARE OF THE INSTRUMENT.

From Porter's "Richard's Steam Indicator."

I.

Of Attaching the Indicator.—When it is practicable, diagrams should be taken from each end of the cylinder. The assumption commonly made, that if the valves are set equal, the diagram from one end will be like that from the other, will be shown by this instrument to be erroneous. This is owing to the difference in the speed of the piston at the opposite ends of the cylinder, which is, at the outer end of a direct-acting engine, from 35 per cent to 66 per cent greater than at the crank-end, the difference varying according to the degree of angular vibration of the connecting-rod. In side-lever or beam-engines, these proportions are reversed, and the speed of the piston is greater at the upper end of the cylinder. Often, also, there is a difference in the lengths of the thoroughfares, and in the lead, or amount of opening, or the point closing; and many times the valves are supposed to be correctly set, when this Indicator will show that they are not. These and many other causes, will make a difference in the diagrams obtained from the opposite sides of the piston.

One use of the Indicator is in fact to show whether or not the diagrams from opposite ends of the cylinder *are* alike.

Pipes to be Avoided.—The Indicator should be fixed close to the cylinder, especially on engines working at high speeds. If pipes must be used, they should not be smaller than half an inch in diameter, and five-eighths in the bends, and as short and direct as possible. Any engineer can satisfy himself with this instrument, that each inch of pipe occasions a perceptible fall of pressure between the engine and the Indicator, varying according to its size and number of bends and the speed of the piston. Diagrams have been known to show, from this cause alone, 40 per cent less pressure than was actually in the cylinder. Probably the diagrams taken from engines, generally show in nine cases out of ten, the lead or the pressure or both, untruly, from the incorrect manner in which the instrument is attached.

Where to Connect the Indicator.—On vertical cylinders, for the upper end, the

Indicator cock is usually screwed into the cover. Sometimes it is attached where the oil-cup is set, this being removed for the purpose. For the lower end, it is necessary to drill into the side of the cylinder, at a convenient point in the space between the cylinder bottom and the piston, when on the center, and screw in a short bent pipe, with a socket on the end to receive the Indicator cock. This Indicator can be used in a horizontal position, but it will be found much more convenient to put in a bent pipe, and set it vertical. Sometimes it will be necessary to drill in the side of the cylinder at the upper end also, especially in double cylinder engines having parallel motions, when the Indicator cannot generally be set on the covers. Care must be taken that the piston does not cover the hole when on the center. No putty is necessary to make these small joints, and it should never be used, as it is liable to clog the instrument. If the screw fits loosely, a few threads of cotton wound round the stem will prevent the escape of steam.

On horizontal engines, the best place for the Indicator is on the top or upper side, at each end; if it cannot be placed there, bent pipes may be screwed into the covers or into the side of the cylinder. In other respects follow the directions given for vertical engines. The Indicator should never be set to communicate with the thoroughfares. The current of steam past the end of the pipe or the hole reduces the pressure in the instrument, and the diagram given is utterly worthless, as any engineer can readily ascertain by making the experiment.

The stop-cock being screwed firmly in its place, screw the Indicator down to its seat, turning it to the most convenient position, and make it fast by turning the coupling; then move the guiding-pulleys to their proper position to receive the cord, and the instrument is in readiness for use.

II.

Of Giving Motion to the Paper.—*The Drum the best Means.*—The revolution of a drum is probably the most correct as well as convenient method of giving motion to the paper. It may be supposed that a flat slide, worked by positive means, would have a perfectly accurate motion; but, in fact, at high velocities, where alone any trouble is met with, the difficulties involved in its use are more troublesome than those presented by the cylinder. In most cases the connecting-rod must necessarily be somewhat long; it must not tremble, or the line on the paper will be tremulous, and the weight required for stiffness, joined to the weight of the slide, causes a momentum, which, if the rod is worked by a vibrating arm, will give to the paper, on each center, a motion opposite to that of the piston of the engine; and precisely at these points it is of the greatest consequence that the two motions shall coincide.

In the use of the cylinder at any speed, the question of obtaining a positive motion, if there is no elasticity in the cord or the parts to which it is connected, is simply one of proportion between the momentum of the revolving parts and the strength of the spring by which this is resisted. In this Indicator these parts are made as light as possible, consistently with other requirements, and the spring is of such strength that they may be reciprocated from 250 to 300 times per minute, without any increase in the length of the diagram, and of course, therefore, without any error in the motion. There is no difference in the construction of these Indicators in this respect, it being intended that every instrument shall be applicable to any engine.

From what Points to derive the Motion.—This may be taken from any part of the engine which has a motion coincident with that of the piston. For a beam-engine a point on the beam, or beam-center, or on the parallel-motion rods where these are employed, will give the proper motion; but care must be taken that the cord be led off in the right direction—a requirement which is sometimes overlooked; afterwards its direction of motion may be changed as required.

In some cases it is most convenient to take the motion from a point on the end of the revolving shaft; this is frequetly the case on horizontal engines, working at high speeds, because then the motion does not need to be reduced. Exact accuracy cannot be got in this way, however, without employing a moving slide and connecting it with the pin in the end of the shaft by a rod or cord of such length that its angular vibration shall be the same as that of the connecting-rod. This will be found generally a troublesome matter, and the engineer will probably prefer, in most cases, to disregard the error resulting from its omission—which is, that the motion of the paper will be more nearly equal at the two ends of the stroke, being slower than that of the piston at the one end, and faster at the other. The crank or pin from which the cord receives its motion must be on its center, relatively to the direction of the cord, whatever that direction may be, precisely when the crank of the engine is on *its* center. If this requirement is not carefully attended to, the diagram will be worthless. Generally, on horizontal engines, the motion of the paper is taken from the cross-head. In an engine-room, a strip of deal board may be suspended from the ceiling in such a manner as to permit it to swing backward and forward, edgeways, by the side of the guides, and motion may be given to it by a pin secured firmly to the cross-head, and projecting through a slot in the board, in which it should fit nicely to prevent lost time on the centers. The board must hang plumb when the piston is in the middle of its stroke. The cord may be connected to this strip of board at a point sufficiently near to its point of suspension to give the required reduction of motion for the paper, and must be led off in a horizontal direction, and then over one or more pulleys in any required direction to the Indicator. At high speeds, however, pulleys should be avoided. On portable engines, the motion may be obtained in the manner just described, the lever swinging from a pin supported in a standard about two feet in height, set on one of the guide-bars.

On locomotives having outside connexions, the motion must be taken from the cross-head. It is indisputably necessary to use only a short direct cord, free from elasticity, and connected to a point, the motion of which is reduced from that of the cross-head by positive means. Care must be taken also to so proportion the parts employed for this purpose, that the point at which the cord is connected shall have a positive motion without any fling, a matter not by any means free from difficulty at 250 revolutions per minute. A rock-shaft, turning in bushings, supported by two angle iron standards precisely over the mid-position of that point of the cross-head from which the motion is derived, affords perhaps the best means of reducing the motion. A long-arm is worked by the cross-head, and a short-arm gives motion to the cord. The short-arm must be keyed in such a position that when the piston is in the middle of its stroke it will stand at right angles with the direction of the cord, whatever that may be.—The direction of the cord may form any necessary angle with the horizontal line, but must be at right angles with the rock-shaft. On locomotives having inside connexions, and a single pair of driving-wheels, where it is practicable, it will be found the better way to take the motion from a pin set in the end of the shaft, and to communicate it by a connecting-rod to a point convenient for attaching the cord. The parts should be all substantially made; the momentum of the connecting-rod will be perfectly resisted by the pin. On oscillating engines, the motion may be taken from the brasses at the end of the piston-rod. If the stroke is long, it is sometimes difficult to reduce this motion to that required for the paper, and in such cases it is necessary to take the motion from an eccentric on the main shaft, to a point as near as possible to the trunnion, and thence to communicate it to the Indicator. In all these connexions, it is of the first consequence that there be *no* lost time which will require to be made up on every center, and will thus cause the paper to stand still while the piston is moving.

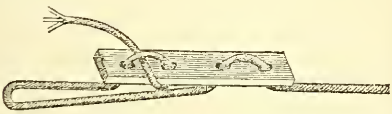
Pulleys of different diameters on the same spindle have been often used as a means of reducing the motion from that of the cross-head, but we do not recommend them; at high speeds it is very difficult to make them answer. The experience of the careful operator will teach him to guard against the various causes of error here mentioned, and others which will arise in the great diversity of situations in which the Indicator is used, and the effects of which are the more mischievous, because often the diagram itself furnishes no means of detecting them. The mathematician will perceive that *perfect* accuracy of motion is attained by only a very few of the methods here suggested. Most of them are only approximately accurate, but they are the best which can be readily employed, and the errors which they involve are too slight to be of practical moment. For the professional engineer, of course, directions are unnecessary.

III.

How to take a Diagram.—*To fix the Paper.*—Take the outer cylinder off from the instrument, secure the lower edge of the paper, near the corner, by one spring, then bend the paper round the cylinder, and insert the other corner between the springs. The paper should be long enough to let each end project at least half an inch between the springs. Take the two projecting ends with the thumb and finger, and draw the paper down, taking care that it lies quite smooth and tight, and that the corners come fairly together, and replace the cylinder. The spring used on this Indicator for holding the paper will be found preferable to the hinged clamp. A little practice, with attention to the above directions, will enable any one to fix the paper readily.

The marking-point should be fine and smooth, so as to draw a fine line, but not cut the paper. It may be made of a brass wire; the best material is gun-metal, which keeps sharp for a long time, and the line made by it is very durable. Lines drawn by German silver points are liable to fade. A large-sized common pin, a little blunted, answers for a marking-point very well indeed; a small file and bit of emery cloth used occasionally will keep the point in order.

To Connect the Cord.—The Indicator having been attached, and the correct motion obtained for the drum, and the paper fixed, the next thing is to see that the cord is of the proper length to bring the diagram in its right place on the paper—that is, midway, between the springs which hold the paper on the drum. In order to connect and disconnect readily, the short cord on the Indicator is furnished with a hook, and at the end of the cord coming from the engine, a running loop may be rove in a thin strip of metal, in the manner shown in the following cut,



so that it can be readily adjusted to the proper length, and taken up from time to time, as it may become stretched by use. On high-speed engines, it is as well, instead of using this, to adjust the cord and take up the stretching, as it takes place, by tying knots in the cord. If the cord becomes wet and shrinks, the knots may need to be untied, but this rarely happens. The length of the diagram drawn at high-speeds should not exceed four and a half inches, to allow changes in the length of the cord to take place to some extent, without causing the drum to revolve to the limit of its motion in either direction. On the other hand, the diagram should never be drawn shorter than is necessary for this purpose.

To take the Diagram.—Everything being in readiness, turn the handle of the stop-cock to a vertical position, and let the piston of the Indicator play for a few moments, while the instrument become warmed. Then turn the handle horizontally to the piston in which the communication is opened between the under side of the piston and the atmosphere, hook on the cord and draw the atmospheric line. Then turn the handle back to its vertical position and take the diagram. When the handle stands vertical, the communication with the cylinder is wide open, and care should be observed that it does stand in that position whenever a diagram is taken, so that this communication shall not be in the least obstructed. The instrument is provided with a stop, to prevent the marking point from tearing the paper. The arm is to be pressed firmly up to this stop. If the line drawn is faint, the point must be screwed up and back if the line is too heavy. The elasticity of the parallel arms gives the light pressure required on the paper. As the hand of the operator cannot follow the motions of an oscillating cylinder, it is necessary that the point be held in contact with the paper by a light spring, and instruments to be used on engines of this class are furnished with an attachment for this purpose. Diagrams should not be taken from an engine until some time after starting, so that the water condensed in warming the cylinder, &c., shall have passed away. Water in the cylinder in excess always distorts the diagram, and sometimes into very singular forms. The drip-cocks should be shut when diagrams are being taken. As soon as the diagram is taken, unhook the cord; the paper cylinder should not be kept in motion unnecessarily, it only wears out the spring, especially at high velocities. Then remove the paper, and minute on the back of it at once as many of the following particulars as you have the means of ascertaining, viz:

The date of taking the diagram and scale of the Indicator.

The engine from which the diagram is taken, which end, and which engine, if one of a pair.

The length of the stroke, the diameter of the cylinder, and the number of double strokes per minute.

The size of the ports, the kind of valve employed, the lap and lead of the valve, and the exhaust lead.

The amount which the waste-room, in clearance and thoroughfares, adds to the length of the cylinder.

The pressure of steam in the boiler, the diameter and length of the pipe, the size and position of the throttle (if any), and the point of cut-off.

On a locomotive, the diameter of the driving wheels, and the size of the blast orifice, the weight of the train, and the gradient, or curve.

On a condensing-engine, the vacuum by the guage, the kind of condenser employed, the quantity of water used for one stroke of the engine, its temperature, and that of the discharge, the size of the air-pump and length of its stroke, whether single or double-acting, and, if driven independently of the engine, the number of its strokes per minute, and the height of the barometer.

The description of boiler used, the temperature of feed-water, the consumption of fuel and of water per hour, and whether the boilers, pipes and engine are protected from loss of heat by radiation, and if so to what extent.

In addition to these, there are often special circumstances which should be noted.

IV.

How to Keep the Indicator in Order.—The Indicator will not continue to work well, unless it is kept in good order. When used, it generally becomes full of water, which will rust and thus weaken the spring, and the steam often contains impurities and grit, a portion of which is lodged in it. After the Indicator has been used, and before putting it up, unscrew the cover of the cylinder case, and draw off the upper ferule, with the pencil movement and the piston and spring attached, empty the water from the cylinder case, carefully clean and dry all the parts, and replace them, lubricating the cylinder with a few drops of oil which is entirely free from gum. The cylinder is not to be removed from the case under any circumstances; the operation above directed gives complete access to it.

Sometimes the surfaces of the piston and cylinder become scratched or roughened by impurities in the steam, a fact which will be detected at once in the diagram by the unsteadiness of the line. If this shows the existence of any obstruction to the perfectly free action of the Indicator, take the instrument apart, as for cleaning, and remove the spring, then replace the piston in the cylinder after cleaning and lubricating them; screw on the cover to guide the stem, and rub the piston up and down in the cylinder, at the same time revolving the stem between the thumb and finger. The surfaces will quickly wear each other smooth; no grinding or polishing material should be used, but the piston should be taken out once or twice during the operation, and the surfaces cleaned. The piston, if dry, ought to drop perfectly free from every position. Before replacing, lift the levers and let them fall, to see if their action also is entirely free.—Then replace everything, taking care to screw the heads of the spring firmly up to the piston and cover. The paper cylinder requires to be lubricated occasionally with a drop or two of pure oil applied at the end of the arbor, also the leading pulleys and the joints of the pencil movement.

V.

How to Change the Springs.—Unscrew the coupling from the end of the piston-stem, the cover from the cylinder-case, and the spring from the piston and cover; introduce the new spring, and screw all up firmly again.

The length of the springs for the different scales are so proportioned to each other, that the pencil will always come to the proper position for drawing the atmospheric line. In putting in the spring No. 1, the head from which the barrel projects to stop the compression of the spring should be screwed to the cover and not to the piston. Be careful that the heads are screwed up firmly to the piston and cover.

The spring which gives reaction to the paper cylinder is liable to break after considerable use, especially on engines running at high-speeds, for which reason this cylinder should never be left to run unnecessarily. When breakage occurs a new spring can be readily substituted, as follows: set the Indicator on the engine, if there is no other convenient means for holding it firmly, and remove the cover of the spring case and the broken spring. Then hook the new spring on to the hook projecting from the ferule on the arbor, coil it into the case, and hook the end on the rim; see that it is coiled in the same direction with the cord. If the string has not sufficient strength to keep the cord quite tight, another coil must be given to it, but it should not be coiled any tighter than is necessary for this purpose.

Prices of Springs and Metallic Paper.—The springs and metallic paper may be procured from any parties who sell these Indicators. The springs will be sent free by post to any address, on receipt of the price in stamps.

	Prices. £	s.	d.
Piston springs, with boxwood scales, each.	0	10	0
Paper cylinder springs	0	1	6
Quire of metallic paper, cut into 360 diagram sheets	0	4	0

Indicators for special purposes, or containing special modifications, will be made on application.

THE CENTRIFUGAL FORCE OF BELTS.

By W. J. Macquorn Rankine, C.E., LL.D., F.R.S.

From "The Engineer."

OBJECT OF THIS COMMUNICATION.—It is well known, through practical experience, that a belt for communicating motion between two pulleys requires a greater tension to prevent it from slipping when it runs at a high than at a low speed. Various suppositions have been made to account for this—such as that of the adhesion to the belt of a layer of air, which at a very high speed has not time to escape from between the belt and the pulley. But the real cause is simply the centrifugal force of the belt, which acts against its tension, and therefore slackens its grip of the pulleys. I have not hitherto seen or heard of any investigation of the laws of the action of centrifugal force on belts and other flexible connecting bands in machinery; and therefore, although it is unlikely that the subject has up to this time wholly escaped the notice of mathematicians, it appears to me that it may be useful to publish an account of the general nature of such an investigation and a statement of the practical rules to which it leads.*

For brevity's sake, the word "band" will be used throughout this paper to denote any flexible connecting piece by means of which motion is communicated between pulleys, whether a belt, a cord or a chain.

CENTRIFUGAL TENSION OF AN ENDLESS BAND.—The general principle of the tension produced in an endless band by centrifugal force is closely analagous to that which forms the foundation of the "hypothesis of molecular vortices," a hypothesis proposed in 1849† as a means of deducing the dynamical theory of heat from the general laws of dynamics, viz.: that a vortex or endless circulating stream produces an outward pressure against the inside of any vessel within which it may be contained, of an amount proportional to the weight of matter contained in an unit of length of that stream, and to the square of its velocity, and independent of the figure of the stream; for it can be proved, from the elementary laws of dynamics, that if an endless band of any figure whatsoever runs at a given speed, the centrifugal force produces an uniform tension at each cross-section of the band equal to the weight of a piece of the band, whose length is twice the height from which a heavy body must fall in order to acquire the velocity of the band.

In symbols, let w be the weight of an unit of length of the band; v the speed at which it runs, and g the velocity produced by gravity in a second (=32·2 ft. or 9·81 meters); then the *centrifugal tension* (as it may be called) has the following value:

$$\frac{w\,v^2}{g} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

There are different ways of demonstrating that proposition, the simplest being as follows: Consider any pair of cross sections of the band at which the motions of the particles are parallel and contrary. Call those cross sections A and B. The weight of band which passes any given cross section in a second is $w\,v$; the particles at A are moving with the velocity $+v$, and the particles at B with the equal and contrary velocity $-v$; hence, in each second, a mass of matter of the weight $w\,v$ undergoes a change of velocity amounting to $2\,v$; and, according to the second law of motion, the force in units of weight required to produce that change is $\frac{w\,v \times 2\,v}{g} = \frac{2\,w\,v^2}{g}$. One half of that force is supplied by the tension at A, and the other half by the tension at B; therefore the tension at each of those points is $\frac{w\,v^2}{g}$; and the same demonstration may be applied to every pair of points in the band at which the motions are contrary.

EFFECT ON THE BAND WHEN IN MOTION.—The effect on the band when in motion is, that at any given point the tension which produces pressure and friction on the pulleys, or *available tension*, as it may be called, is less than the total tension by an amount equal to the centrifugal tension; for this amount is employed in compelling the

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* The general law of the centrifugal tension of a band is demonstrated in "Thomson & Tait's Elementary Dynamics" (Oxford, 1868); but it is not applied to questions of practical mechanics, which are foreign to the subject of that treatise.

† See "Transactions of the Royal Society of Edinburgh," Vol. XX, 1850–1851.

particles of the band to circulate in a closed or endless path. It is, of course, to the total tension that the strength of the band is to be adapted; therefore the transverse dimensions of a band for transmitting a given force must be greater for a high than for a low speed.

RULE FOR WEIGHT OF BAND.—One of the most convenient ways of expressing the size of a band is by stating its weight per unit of length—for example, in pounds per running foot, or in kilogrammes per meter. When the size is expressed thus, the corresponding way of expressing the intensity of any stress on the band is in lineal units of itself, such as feet or meters. Let b denote the greatest safe-working tension on a band of a given kind, in units of its own length; w, as before, the weight of an unit of length; so that $w\,l$ is the amount of the safe-working tension in units of weight. Let T be the amount of the available tension required at the driving side of the band for the transmission of power, being usually from two to two and a half times the force to be transmitted. Then the total tension is

$$T + \frac{w\,v^2}{g} = w\,l \quad . \quad . \quad . \quad (2)$$

whence it is obvious that the required weight per unit of length is given by the following formula—

$$w = \frac{T}{l - \frac{v^2}{g}} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

For example, suppose that the band is a wire rope—that the greatest working tension is to be equivalent to the weight of 2,900 ft. of the rope, and that it is to run at 100 ft. per second, then we have

$$l = 2900 \text{ ft.};$$

$$\frac{v^2}{g} = 310 \text{ ft.};$$

and consequently the weight per running foot of the rope required is

$$w = \frac{T}{2900 - 310} = \frac{T}{2590};$$

or about one-eighth part heavier than the rope required for a speed so moderate as to make the centrifugal tension unimportant.

In fixing the value of the greatest working tension on a wire rope, a proper deduction must of course be made for the stress produced by the bending of the wires round the pulleys. That stress is given *in equivalent length of rope* by the expression $\frac{L\,d}{D}$ where D is the diameter of the smallest pulley round which the rope passes, d the diameter of the wire of which the rope is made, and L the modulus of elasticity of the wire, *in length of itself*—viz., about 8,000,000 ft. or 2,400,000 meters. That is to say, let l be the length of rope equivalent to the greatest safe-working tension on a straight rope; l, as before, the length equivalent to the actual greatest working tension, then

$$l = l_1 - \frac{L\,d}{D}{}^* . \quad . \quad . \quad . \quad (4)$$

In the case of leathern belts b may be estimated at about 660 ft. or 200 meters.

In the case of a leather belt running at the rate of 100 ft. per second, the weight per unit of length required in order to exert a given available tension is increased in the ratio of $\frac{660}{660-310} = \frac{660}{350}$, or to nearly double, as compared with that of a belt whose centrifugal force is unimportant.

The *sectional area of a leathern belt* may be calculated approximately in square inches by multiplying the weight per running foot by 2.3, or in square millimeters, by multiplying the weight in kilogrammes to the running meter by 1,000.

The ordinary thickness of a single belt being about 0.16 in., or four millimeters, the breadth may be deduced from the sectional area by dividing by that thickness.

The length (L) equivalent to the modulus of elasticity of a leathern belt, as calculated from Bevan's experiments, is about 23,000 ft., or 7,000 meters.

TENSION OF A BAND WHEN AT REST.—It is sometimes requisite to determine the tension which ought to be put upon the two sides of a band when at rest, in order that, when in motion, given tensions may be exerted at the driving and returning sides. The ordinary rule is to make that tension the arithmetical mean between the intended *available tensions* at the driving and returning sides of the band; and when the speed is such that the effect of centrifugal force is unimportant, that rule is sensibly correct.

It is sensibly correct also when the band connects two pulleys that stand a long way apart; for example, in Hirn's system of "Telodynamic Transmission," where the spans between the pulleys, that are connected by means of an endless wire rope, are sometimes 150 meters, or about 500 ft.

On the other hand, when the pulleys con-

* See Reuleaux, *Constructionslehre für Maschinenbau.*

nected by means of a fast-running band are comparatively near together, the tension which should be put upon each side of the band when at rest is nearly equal to the arithmetical mean between the *total tensions* of the two sides of the band when in motion; that is, the centrifugal tension has to be added to the tension given by the preceding rule.

In intermediate cases the tension, when at rest, has values intermediate between those given by the two preceding rules; and when the band connects two pulleys, whose axes are at or near the same level, it is expressed by the following formula, the result of a mathematical investigation, of which it is unnecessary to give the details here. Let l, as before, denote the length of band whose weight is equivalent to the total tension at the driving side when in motion; l' the corresponding length for the returning side; L the length equivalent to the modulus of elasticity; c the *half span*, or half distance between the pulleys; l_0 the length of band whose weight is equivalent to the tension required when at rest. Then, to a degree of approximation sufficient for practice, we have

$$l_0 = \frac{l+l'}{2} - \frac{v^2}{g}\frac{Lc^2}{2}\left\{\frac{1}{3l^3+Lc^2}+\frac{1}{3l'^3+Lc^2}\right\} \quad (5)$$

The two extreme cases, to which the two rules already given apply, are expressed as follows: When $\frac{Lc^2}{3l^3}$ is a very large number, we have l_0 nearly $= \frac{l+l'}{2} - \frac{v^2}{g}$, being the mean between the available tensions of the two sides; and when $\frac{Lc^2}{3l^3}$ is a very small fraction, we have

$$l_0 \text{ nearly } = \frac{l+l'}{2};$$

being the mean between the total tensions of the two sides of the band.

For example, let the band be a wire rope; let $v = 100$ ft. per second; so that $\frac{v^2}{g} = 300$ ft. Let the total and available tensions, when in motion, be as follows:

Driving side, $= 2,900;\ l - \frac{v^2}{g} = 2,590$

Returning side, $l' = 1,605;\ l' - \frac{v^2}{g} = 1,295$

Means,

$$\frac{l+l'}{2} = 2,252.5;\ \frac{l+l'}{2} - \frac{v^2}{g} = 1,942.5$$

Let $L = 8,000,000$ ft. of rope, and let the pulleys be 200 ft. apart, so that the half span $c = 100$ ft.; then the required tension at rest is found to be equivalent to the weight of the following length of rope:

$$2,252\tfrac{1}{2} - 215 = 2,037\tfrac{1}{2} \text{ ft.};$$

being intermediate between the mean of the total tensions and the mean of the available tensions, and somewhat nearer to the latter than to the former.

In order to show, in a general way, how the results expressed by the formulas and the rules are arrived at, it may be stated that the variations of the total tension, when the speed of the band alters, depend upon alterations in its length. When the pulleys are very near each other, the two sides of the band are sensibly straight, and its alterations of length are insensible, so that the total tensions at rest and in motion are sensibly equal, and the centrifugal tension takes effect almost wholly in diminishing the available tension. When, on the other hand, the pulleys are far apart, the two sides of the band hang in the form of curves; the band is free to alter its length to a certain extent; and part of the centrifugal tension takes effect in lengthening the band and increasing the total tension, instead of in diminishing the available tension; and hence the mean total tension is somewhat greater than the tension when at rest, and the available tension is not so much diminished as in a shorter band. If the span between the pulleys is wide enough, nearly the whole of the centrifugal tension takes effect in lengthening the band and increasing the total tension; and the mean available tension remains sensibly undiminished.

This accounts for a fact, well known to practical men, that in transmitting a given power between a given pair of pulleys, a long belt is less liable to slip than a short belt.

Coal from Sea-weed.—Some time ago the practice was introduced of converting marine algæ by calcination into an excellent coal superior to ordinary wood charcoal for filtering water, disinfecting sinks, polishing glass and correcting the acidity and decolorizing wines,—also for precipitating and decolorizing vegetable alkaloids.—Until recently no value was attributed to the marine algæ—to-day it is an important article of commerce in several islands.—*Annales du Génie Civil.*

EXPLOSIVE COMPOUNDS FOR PROJECTILES.

From "The Mechanics' Magazine."

Gunpowder, which has been in use for so many years, may now be considered as perfect as it can be made, as regards projectile force and uniformity of combustion. Recent attempts have been made to employ it in a more condensed form, by compressing the charges, but these have failed to a great extent. Of late years, several new explosive compounds have been manufactured as substitutes for gunpowder, and they have, for the most part, been described in our columns. It is claimed for them, generally, that they possess greater cleanliness, almost total absence of smoke, less sensible recoil for a given velocity of projectile, and reduction of danger in manufacture, as being less violently explosive in an unconfined state.—These may be considered as the general claims to superiority of the new explosives. Being principally composed of vegetable fibers nitrogenized, they might aptly be termed explosive fibers. Those now in use are known as gun-cotton, wood-powder, and gun-felt. As a few years' experience only in the production of these compounds can be placed against as many centuries in the production of gunpowder, it is reasonable to expect further progress and improvement in these new substances. When gun-cotton was first discovered, its obvious advantages induced several governments to adopt it in the place of gunpowder. The nature of this substance, however, not being thoroughly understood, many serious accidents resulted from its use. The too rapid combustion injured arms in which it was employed, and it was further found to lack uniformity in firing; in fact, for the most part, gun-cotton was abandoned in disgust. Recently, however, many ingenious methods have been adopted to retard this great rapidity of combustion, and although gun-cotton can be and is used in shot-guns with comparative safety, still it has not yet been produced with sufficient uniformity or slowness of combustion to shoot accurately in rifles. Until this be done, it cannot be considered as a perfect substitute for ordinary gunpowder. Gun-cotton, however, can now be produced in such a condition that it may be stored with safety and without fear of deterioration; and thus prepared, it is largely used for mining and engineering purposes.

Schultze's wood-powder is composed of minute cubes of hard wood, treated in a manner analogous to gun-cotton, and subsequently impregnated with other substances; it is used in a pure state, and requires compressing with considerable force, in order to obtain the best results. It can be fired in rifles, and this is a proof of a certain amount of uniformity, though it occupies a greater volume than gunpowder to give an equal initial velocity to the bullet. Reeves' gun-felt—another comparatively recent invention—is composed of vegetable fibers, which are also treated analogously to gun-cotton, and subsequently impregnated with other materials. This compound is also used in a pure state, and can be fired in rifles. This material was invented and is now being manufactured by Messrs. Reeves & Co., of Glastonbury. It has been found to answer exceedingly well, both in sporting guns and in rifles, but, pending some practical trials which are to be made with this material in a short time, we defer a further reference either to its composition or its special performances. These two last mentioned compounds are made of several different strengths, and the weight of charges used relatively to gunpowder is, of wood-powder, about one-half, and gun felt one-third, *i. e.*, one is three times and the other double as strong as ordinary powder. These new explosives ignite at a much lower temperature than powder, but being composed of less solid matter, the combustion generates less heat, and as many rounds can be fired in a gun or rifle with as much safety as with gunpowder. The fouling is also considerably lessened; the ignition, although quick, does not impart the same sensible recoil. The more solid forms of fiber, such as wood-powder, give more recoil than gun-felt, from which it may be inferred that the elasticity of a compound to a certain extent checks in itself the sudden shock of ignition.

The reduction of recoil in military weapons is of some importance, as it limits the weight and velocity of the bullet. Action and reaction on the bullet and breech of gun may be the same, but when the gases are generated in a gradual manner, the sensible recoil must necessarily be reduced. Even with gunpowder this can be proved by experiment, as quick burning powder will give much greater recoil, with the same initial velocity imparted to the bullet, than a slow burning one. No doubt, the great portion of the motive power exerted by explosives is instantaneous in its action, and ought not to be generated before it is required to act on the projectile. A gas, doubtless, is elastic according to its density, and, if permanent in this respect (such as steam or compressed air), could not be generated too quickly to give velocity to a projectile. But with all explosives, the reverse has been shown to be desirable, *i. e.*, provided a given charge will consume in a barrel before a bullet quits the muzzle of the arm. The slower the combustion the greater the velocity communicated to the bullet, the friction in the barrel being greatly reduead. Last year, a public trial took place with a view of testing the new explosive substances. Some very fair shooting was made with wood-powder and gun-felt at 100 yards' range in rifles, the latter equalling gunpowder in accuracy, and the former within 30 per cent of it. If there is to be any competition this year, it is to be hoped that it will be at long ranges, that being the true test with rifles, reference being made to the angle of elevation and absolute deviation. As already intimated, some further comparative experiments are to be made with Schultze's wood-powder and Reeves' gun-felt, to which we look forward with interest, and the results of which we shall place before our readers.

UNDULATING AND LEVEL RAILWAYS.

RELATIVE EXPENSES OF TRACTION.

From "Engineering."

A problem often and long discussed by railway engineers abroad is that known as the "equation of gradients;" or, in other words, what additional length of line, taken as level, is represented by given gradients of a given length and inclination? Two lines are, each, 100 miles in length. One is, we will suppose, a dead level; the other has rising and falling gradients, ascending and descending at rates varying from 1 in 1,000 to 1 in 60. How much longer, not in actual distance, but in respect of working expenses, is the latter than the former? We are in the habit of lumping all railway expenses at so much "per train mile," the train being either passenger or goods, and containing, in the former case, anywhere from 15 to 1,000 passengers, and in the latter, anywhere from 20 to 300 tons of goods. But we are to suppose the same trains over both the lines just assumed. Let the undulating line start with a mile of level, then five miles up of 1 in 1,000, then four miles up 1 in 100, then two miles more up 1 in 80, to a summit 369.6 ft. above the starting point. Let it then run eight miles on a level; then descend at the rate of 1 in 200 for five miles, falling 132 ft.; then five miles of level; then ten miles up 1 in 264, *i. e.*, rising 200 ft.; then five miles up 1 in 132, rising 200 ft. more to a point 637.6 ft. above the base. Let it then have five miles more of 1 in 60, or an additional rise of 440 ft., giving a summit, midway between the termini, 1,077.6 ft. above the starting point. Let the line then descend at the rate of 1 in 200 for five miles, falling 132 ft., then rise for ten miles at the rate of 1 in 400, thus rising again to the summit of 1,077.6 ft. Let it then descend for twenty miles at the rate of 1 in 132, thus falling 800 ft. Let the line fall thence for ten miles at the rate of 1 in 264, the fall being 200 ft., and let the remaining fall of 77.6 ft. take place in the last five miles.

Those who take any interest in the subject will sketch out the profile for themselves; those who do not will turn to another column and read something else.

It will be seen that the line has a maximum gradient of 1 in 60 for five miles in one direction, and a maximum of 1 in 132 for twenty continuous miles in the other. The sum of the ascents from either terminus would be 1,341.6 ft., while the total rise and fall would be, of course, twice as much, both termini being at the same level. Supposing the same trains to be run over the level and the undulating line, how much longer is the latter than the former—not in actual measurement over its various undulations, for that is easily calculable, and in any case very little—but what length of level line could be worked at the same expense? It will require but little consideration to perceive that the question involves many points as to speed, number of stops, position of stations, the preponderance, if any, either way, of the traffic, &c.

Suppose, however, trains of a total weight, including engine, of 100 tons, are to be run through, each way, stopping only midway. The speed on the level line to be 40 miles an hour, requiring $2\frac{1}{2}$ hours running time. The resistance, by Clark's formula, would be 1,735 lbs., corresponding, at 3,520 ft. per minute, to 185 horse power maintained for $2\frac{1}{2}$ hours.

On the undulating line the train, apart from all other resistances, would be lifted 1,341.6 ft. in ascending the various gradients from either end, and if this ascent occupied an hour and a half, the average work expended upon gravity during that time would be 101 horse power. For

$$\frac{224{,}000 \text{ lbs.} \times 1341.6 \text{ ft.}}{2{,}970{,}000 \text{ ft. lb.}} = 101 \text{ H. P.}$$

The 224,000 lbs. being the weight of the train, and the divisor, 2,970,000, the number of foot pounds in a horse-power, exerted for an hour and a half; corresponding to 33,000 ft. lb. in one minute. If the mean speed of ascent from one end of the line to the half-way summit be 33⅓ miles an hour, as above assumed in the estimate of an hour and a half, the resistances other than gravity will be

$$8 + \frac{33.3^2}{171} = 14.5 \text{ lb. per ton, or } 1{,}450 \text{ lbs.}$$

for the entire train, at 2,933⅓ ft. per minute, corresponding to 129 horse-power, or, including gravity, to 230 horse-power for an hour and a half, as against 185 horse-power for an hour and a quarter in doing the same distance on a level.

But we now come to the descent, and here it is difficult if not impossible to estimate—not the resistances to motion—but the exact practical effect of descending gradients upon the cost of working. Less fuel and water are of course used, but the actual forces at work upon a train are the same, at a given speed, in descending as in ascending an incline; the difference being merely that gravity takes the place of steam power. If, indeed, as is almost certain to be the case, the speed be greater in going down than up a given incline, on a double line—and supposing the traffic to be equal in both directions—the rails on the down side will, after a time, be invariably found to be more worn than those on the up line, although they are not subjected to the same grinding action from the driving wheels of the engine. Almost the only saving on down gradients is in fuel and water. If no steam be used the cylinders must be kept well lubricated, the attendance or cost of engineman and fireman, is the same, the wear and tear, except upon the fire-box and tubes of the engine, is certainly not less, and if it be necessary to put on the brakes, it is apt to be more. In these respects alone, long down gradients, of considerable inclination, may be taken as involving a working cost equal to that of levels, although, unfortunately, no data are at hand to show that they are neither better nor worse than levels. There are other and considerable items of expense which are wholly independent of gradients.

Regarded, then, as levels, the descending gradients either way from the midway station would require the exertion of 185 horse-power for an hour and a quarter, the ascent requiring 230 horse-power for an hour and a half, thus giving a mean expenditure of 209½ horse-power for 2¾ hours on the undulating line, as against 185 horse-power for 2½ hours on the level. Allowing for both the greater horse-power and longer time on the undulating line, it would be 24½ per cent, or, say one-fourth more expensive in working than the level. In other words, the 100 miles of undulating line are practically 110 miles in point of time and 124½ miles in point of cost of working, as compared with the 100 miles of level line. This estimate assumes that the cost of fuel, repairs, wages, &c., are in the exact ration of the horse-power exerted, after adopting the explanation given in respect of descending gradients.

The assumptions which enter into these estimates are by no means conclusive, and they would be greatly affected by the substitution of heavy slow traffic in place of fast passenger traffic. Thus, in the American States, the rule for the "equation of grades" known as Latrobe and Knight's, is to divide the sum of the ascents and descents in feet, by 52.8, and to add the quotient to the length of the line in miles, as the equivalent length of level line. By this rule, the total rise and fall of 2,683.2 ft., in our suppositious line would represent $\frac{2{,}683.2}{52.8} = 50.8$ of additional length, and with a moderately slow goods traffic, this addition would hold good in practice.

There are various aspects of the question of gradients, and different engineers would doubtless take different views of it. But the extra expenditure of power must be as the total rise of the line, and is, in a measure, independent of short, steep and exceptional gradients. With a train of a total weight of 100 tons, any engine with 15 tons of adhesive weight should have no difficulty in dealing with it on a gradient, however long, of 1 in 60; and if the gradient were not above five miles long, occupying ten minutes in the ascent, at the rate of thirty miles an hour, the boiler power required would not be found excessive, supposing the water well up and the pressure high, on entering upon the gradient.

In taking out the cost of working as 24½ per cent more upon the undulating than upon the level line, this represents much more than the extra fuel used, and more than the extra wages incurred. It represents, perhaps, more properly, the increased cost of lubrication and repairs, including repairs of permanent way. Of the latter, however, a large share is due to climatic and local causes, and is independent both of the resistance of trains and the amount of traffic. A large proportion of the general traffic expenses is wholly independent of the resistance of trains, so that, as affecting dividends, the gradients assumed would not probably diminish the net earnings derivable from a level line by more than 6 per cent, equal perhaps to 1 per cent on the capital of the line.

Compound Steel and Iron Rails.—Mr. Ashcroft has laid a quantity of compound rails on the Charing Cross line. The top member is a Bessemer steel ┬. The two bottom members are wrought iron angle pieces _| |_, bolted together. The rails are said to answer well. Much attention is being directed in this country to the production of a good compound steel and iron rail. The old compound iron rail, with a split head, failed chiefly by the mashing down of the iron into the continuous crack in the head, and the forcing apart of the two members. The compound rail, with a solid head and a split foot, did tolerably good service; the grand defect was the riveting of the two members together so tightly that they could not slip upon each other when expanded by heat. Making the top member of steel and bolting the two together, would undoubtedly make a durable rail. The general plan of Mr. Ashcroft would, however, appear to be better. A modification of this plan is being developed at one of our rail mills.

Steel-headed rails should be cheaper than all steel rails, and they should give nearly all the advantages of steel as far as wearing is concerned. Of course they cannot be so stiff nor so strong as all steel. The use of three, or even of two members, overlapping each other, almost insures against disasters from broken rails. Steel heads welded to iron piles do not possess this advantage, although there is much to be said in their favor. The different plans will be considered at another time. The attention of experts is just now chiefly directed to the production of compound rails with steel heads. Besides immunity against accident from breaking, another great advantage expected from this construction is the permanence of the iron parts. It is believed that the steel heads only will require renewal; and this only after they have worn a dozen times as long as iron heads; and that the iron angle pieces forming the flanges and web of the rail will be practically indestructible. There must, we think, be some wear between the parts thus subjected to abrasion. Nevertheless the economy to be reasonably expected from compound steel and iron rails is very great, and it is probable that railway companies will hasten to avail themselves of the proposed advantages as soon as they are offered.

Coiled Tube Boilers.—It was once thought that the perfection of boiler construction had been arrived at in boilers made on the coiled tubular system. This principle, however, soon showed a radical defect which led to its abandonment. Boilers so constructed failed on account of the tubing becoming red hot when the engine was standing, and the force pump was consequently not acting. This defect, however, has been practically overcome by Mr. Thomas Mills, of England, in an invention described by the London "Mechanics' Magazine." Mr. Mills constructs the fire-box of a boiler, of the upright form, of a coil of tubing enclosed in a case, the fire-box being contained within the coil. The bottom of the coil is connected by a tube brought down outside the casing from the upper part of the boiler, at the lower end of which tube is fixed a self-acting valve placed in a horizontal position, which allows the water to pass on into the coil. The expansion of the water caused by its coming in contact with the heated tubing closes the valve after it has passed through it, and thereby prevents a backward flow of water through the outside tube, and forces the water and steam on through the coil into the upper part of the boiler again. After this, the valve again opens, in consequence of the downward force of the water in the outside tube, thereby creating a perfect circulation through the coil, the discharge end of the coil being brought up inside through the bottom of the upper part of the boiler above the water level. The coil can also be supplied with water by means of a pump worked by the engine (the stroke of the pump being altered according to the quantity of water required to supply the boiler), and cutting off the other supply of water by means of a cock fixed in the outside tube connecting the upper part of the boiler with the lower end of the coil, thereby feeding the boiler with water through the coil without in the least degree reducing the volume of steam. This method of feeding the coil by the outside tube and valve brings the water direct into the hottest part of the coil, and keeps up a perfect and continuous circulation without the aid of the force pump. This pump is used to feed the boiler through the coil, which is a great advantage in itself, as the cold water does not come into direct contact with steam contained in the upper part of the boiler, which causes loss of steam by condensation. Mr. Mills has made practical trials of this improved system of construction, and finds it to realize the following advantages—economy in every respect, rapid generation of steam, great strength, and almost entire freedom from explosion, together with lightness and simplicity. He states that it raises steam from cold water in less time than any other boiler at present in use. The circulation through the coil being exceedingly rapid, no deposit is found to remain in it. The self-acting valve or clack is so simple in construction that it cannot fail.—*American Railway Times.*

WORKING HEAVY GRADIENTS.

Compiled from a paper before the Institution of Civil Engineers, (Feb. 2, 1869,) by Mr. James R. Mosse, M. I. C. E., on the "Mauritius Railway—Midland Line."

The Gradients.—The character of the gradients on the Midland line will be understood from the following summary: From Port Louis to the summit there was a rise of 1,817 ft., the distance being about 16 miles, or equal to an average gradient of 1 in 46.68; and from the summit to Mahebourg, a distance of about 19 miles, there was a descent at the rate of 1 in 55.61. For about 12½ miles before reaching the summit the inclination was on an average of 1 in 41.17, and thence for about 13½ miles the line fell on an average 1 in 45.06. The steepest gradient was 1 in 27, of which there was a total length of 13,526 ft., the greatest continuous length of this gradient being 6,163 ft., and the next longest 5,016 ft. The next in severity was 1 in 30, the total length being 9,526 ft., the greatest length of this gradient being 3,000 ft., and several lengths of about 2,000 ft. each. The ascending gradients varied from 1 in 27 to 1 in 60, while the descending gradients towards Mahebourg varied from 1 in 30 to 1 in 60. The curves varied from 950 ft. radius to 6,000 ft. radius, and the lengths of these curves ranged from 200 ft. to 3,200 ft. The ordinary radii were generally from 2,000 ft. to 3,000 ft. The sharpest radius which occurred on the steepest gradients of 1 in 27 and 1 in 30 was 1,600 ft., the greatest continuous length of this curve being 900 ft. on the former gradient, and 1,930 ft. on the latter. The next radius in severity was 2,000 ft. on the maximum gradient of 1 in 27, the greatest continuous length of this curve being 1,000 ft. Reverse curves of this radius 1,920 ft. in length were also found on the maximum inclination of 1 in 27. On descending from the summit to Mahebourg the line from the 17th mile to the 19th mile might be said to be composed wholly of reverse curves, and at the 29th mile the radius was only 1,400 ft., the length of this curve being 1,980 ft., chiefly on a gradient of 1 in 30. Of curves under 2,000 ft. radius there was an aggregate length of 21,165 ft; of those ranging from 2,000 ft. to 4,000 ft. radius there was a length of 49,710 ft.; and of curves from 4,000 ft. to 6,000 ft. (the greatest radius), there was an aggregate length of 25,560 ft., the total length of curves being 96,435 ft., and of the straight portions of the line 89,467 ft.

The Locomotives.—The locomotives furnished under the original contract for working these inclines were seven in number and of the following description: they were tank engines, having cylinders 16 inches in diameter, with a length of stroke of 22 in.; the wheels, six in number, were 3 ft. 6 in. in diameter, and were all coupled, the length of the wheel-base being 15 ft. When supplied with water and fuel these engines weighed nearly 37 tons, and they were worked with a pressure of steam of 120 lbs. per square inch. Subsequently six larger saddle-tank locomotives were designed by Mr. Hawkshaw, having the following dimensions: cylinders 18 in. in diameter, with a length of stroke of 24 in.; the wheels, eight in number, were 4 ft. in diameter, and were all coupled, the length of the wheel-base being 15 ft. 6 in. When supplied with water and fuel, these engines weighed nearly 48 tons, and they were worked with a pressure of steam of 120 lbs. per square inch. The center pairs of wheels (one of which was the driving pair) were fixed stiff on the frame; but in order to pass easily round the curves, both the leading and the trailing wheels had three-quarter inch play on each journal, and the joints of the coupling rods, connecting these wheels with the driving pair, were fitted with a ball and socket, so as to allow the requisite motion. All the engines were manufactured by Messrs. Sharp, Stewart & Co., and worked very satisfactorily. These engines would, with passenger trains, take five carriages and one brake-van, equal to a load of 42 tons, though on some occasions they had hauled eight loaded vehicles, weighing in all about 56 tons; while with goods trains the usual load with the lighter locomotives was 70 tons, and with the heavier locomotives from 100 tons to 120 tons. It should, however, be stated that by reducing the lead of the slide valves to one-eighth of an inch, the power of these engines had recently been increased 10 per cent.

Speed and Duty.—The average speed of the passenger trains, including stoppages, was 12 miles per hour between Port Louis and the summit, and 15 miles per hour from Mahebourg to the summit; while that of the goods trains was about 9 miles an hour, including frequent stoppages. The particulars of a trip made on the 12th December, 1867, when the fuel and water were noted more accurately than usual, were given in detail. From these it appeared that the train consisted of ten loaded wagons weighing together 83 tons, or with the engine a gross load of 131 tons; the average speed from Port Louis to the summit was 11 miles per hour, and taking the average pressure of steam in the cylinder as 60 lbs per square inch, the power exerted would be $\frac{131\times60\times11\times88}{33,000}=230$ H. P. or, not including the weight of the engine, 146 H. P., and this, divided by the weight of the locomotive, was equal to 3.04 H. P. per ton of motor. The coal used on the above trip was obtained from Sydney, N. S. W., and the consumption amounted to 4.75 lbs. per H. P. per hour, 8 lbs. of water being evaporated by 1 lb. of coal, but ordinarily only $7\frac{1}{2}$ lbs. of water were evaporated by 1 lb. of this coal.

Carriages and Brakes.—With the exception of the first-class carriages all the others on this railway had a brake on every wheel, worked from the inside. The ordinary passenger trains were composed of one first, one second, and two third-class carriages, with one brake-van, and to these trains Mr. Clark's continuous brake was attached. This apparatus was worked by a chain, which tightened the brakes on every one of the wheels simultaneously. The brakes were taken off by heavy counter-balance weights, resting longitudinally over the chain in the center of the carriage, between the front and end wheels. This apparatus was sufficiently powerful to lock every wheel, and had worked satisfactorily; for during two years there had not been a single fracture of the chain, nor of any of the working parts. It, however, required careful management, and must be applied gradually, before the train had acquired serious momentum. The brake-van of every passenger train was now provided with sand boxes leading to the rails, as formerly the dew on the rails wetted the wheels of the brake-van, and prevented the friction rollers of the apparatus from revolving; whereas, as soon as sand was applied, the wheels became dry, and the friction rollers acted efficiently. Every train of four or five carriages had two guards, one to work the continuous brake, the other to use the separate brake, if necessary, attached to that carriage which was not connected with the continuous brake. The heaviest passenger train which had descended from the summit to Port Louis consisted of fourteen carriages and two brake-vans, conveying five hundred and thirteen troops. That was on the 14th November, 1868, and it was kept perfectly under control by the continuous brake on four carriages, and by five additional brakesmen, the speed being steadily maintained at 20 miles per hour. There were but four instances of passenger trains getting for a time beyond control: first, one morning when the rails were wet, a train descended from the summit for a distance of $3\frac{3}{4}$ miles in five minutes, or at a speed of 45 miles per hour. This was the highest speed on record, and it occurred before the sand boxes were put on the brake-vans. Secondly, in a similar way, another train attained a speed of 32 miles per hour. Thirdly, a train overran a station for a considerable distance, chiefly from the want of sufficient care on the part of the engine driver and guards. Lastly, a train once attained an excessive speed in descending from the summit, through the dropping off of the nut of the eyebolt passing through the axle on which the continuous chain of the brake apparatus was wound. The speed in descending the inclines was limited theoretically to 18 miles per hour, practically it rarely exceeded 25 miles, and the carriage brakes were generally sufficient to control the train, without the necessity of applying the engine-brake. The goods trains in descending the inclines as a rule consisted of eight loaded wagons with the lighter locomotives, and of ten or twelve wagons with the heavier engines; and in these cases also the brakes on the wagons, two being screw brakes, and the remaining wagons being furnished with the ordinary lever brakes, afforded power sufficient to control the trains. It had long been in contemplation to make safety sidings at the foot of the steepest inclines, but the ground was by no means favorable for the purpose, and, moreover, it was feared that such sidings might become a source of danger.

Cost of Working.—The rules in force for the regulation of the traffic on the main line and at the stations were then given in detail, as well as the traffic returns for the years 1866 and 1867, the rates for passengers and goods, and the statement of the receipts and expenditure for the year 1866, from which latter it appeared that the working expenses were then $62\frac{1}{2}$ per cent of the receipts; but this result was said to be due to several exceptional causes. Considering the high price paid for skilled labor and for fuel, the agricultural character of the district through which the line passed, the severity of the gradients, the want of anything that could be called a town save at Port Louis, the lack of minerals or manufactures to transport, the peculiar nature of the sugar traffic—requiring a large amount of rolling stock for three months in the year, whereas for the remaining nine months less than half the quantity sufficed—the author thought it was not surprising that the working expenses of the Midland line should in 1866 have been $62\frac{1}{2}$ per cent of the receipts, or 5s. 5d. per train mile. Now that the heavier locomotives enabled a larger amount of sugar to be carried, and when the goods traffic was further developed, it was believed a considerable decrease in the percentage of working expenses to receipts would ensue, accompanied also, it was hoped, by a reduction in the cost per train mile.

Conclusions.—In conclusion it was remarked, that although it might sometimes be impossible to construct a railway with easier gradients than those on the Midland line, yet the difficulty of working these inclines in wet weather had been so great, the load hauled so small, and the speed so low, that the author thought the severity of any gradient for a long rise should never exceed 1 in 40; and that it would always be preferable (under the ordinary system of tractive power), to incur, within reasonable limits, any additional expense that might be requisite to bring the inclination within this ratio. It was also suggested that in laying out such inclines, whatever might be the ruling gradient (provided it was not entirely exceptional, and where additional power could be applied), that gradient should be followed throughout the line, as far as the features of the country would permit. It was likewise recommended, that pieces of level should be introduced between the different inclinations, as they were of the greatest value, in controlling the trains in descending. The Midland line had now been opened for more than three years, and fortunately no accident had yet occurred to any train in descending the inclines.

SUBMARINE ENGINEERING.

SINKING BRICK AND IRON PIERS—SAND PUMP—NEW EXCAVATOR.

From a paper by Mr. Imrie Bell, M. I. C. E., "On sinking wells for the foundations of Piers and of the Bridge over the River Juma, Delhi Railway," and a paper by Mr. John Milroy, Assoc. I. C. E., entitled "Description of Apparatus for Excavating the interior of and for sinking Iron Cylinders," before the Institution of Civil Engineers, March 2d, 1869.

Sinking Brick Piers.—The mode of forming the foundations of the bridge over the river Juma, was thus described by Mr. Bell: It appeared that the bed of the river at this point consisted of coarse and fine gravel and sand, interspersed with layers of blue clay 3 ft. and 4 ft. thick, and covered with silt; but during the rainy season large boulders, weighing 14 lb. each and upwards, were brought down and deposited by the scour of the river 30 ft. below the level of the bed. The bridge comprised twenty-four openings, each 99 ft. in the clear, and the superstructure was composed of two lines of lattice girders, resting on brick columns or wells, each 12 ft. 6 in. external diameter, and 5 ft. 10 in. internal diameter, so that the wall of the well was 3 ft. 4 in. thick. In some instances the sites of the piers were got clear of water by diverting the river at different points during the dry season, while in other cases islands were formed, by driving a half circle of piles on the up-stream side, then lowering sand-bags on the down stream side, to the height of 4 ft. or 5 ft., and afterwards filling up with sand to 5 ft. above low water. The curb on which the steening of the well rested was formed of wrought-iron plates and angle irons riveted together; and in cross section the curb was like an inverted right-angle triangle, of which the height was 4 ft. and the base 3 ft. 4 in. When each curb was complete it was moved into position, and the compartments were then filled in with concrete. The curb was next sunk by men working with the "phaora" (spade) and basket, till the upper edge was within 3 in. of the level of the water, when a ring of brick work was carried up for a height of 6 ft. The excavation of the interior was again proceeded with by means of the "jham" and divers in the old native style; afterwards a further height of 10 ft. of brick work was added, but the material was now removed by a sand-pump (to be hereafter described) worked by a steam hoist of 4-horse power, as was the case after two additional lengths, each of 15 ft., were built, when the well was carried down to its full depth. In operations of this nature great care was necessary, especially at first, to insure the well or cylinder descending vertically. For this purpose the curb should invariably be sunk alone without any building. The first height of brick work should not exceed 5 ft. or 6 ft., the next 10 ft., and it was never advisable to build more than 15 ft. at a time. Before commencing any additional height the top course of the brick work already built ought to be removed, to insure a thoroughly clean surface for the mortar.

Lime and Mortar.—The lime used at the works was made from marl or, more properly, calcareous clay, which, while soft, was roughly moulded into bricks. These were stacked to dry for three or four days, and were afterwards burned with wood in kilns for fifty or sixty hours. The flues were then closed with bricks and mud, and so allowed to remain for two or three days. On the kiln being opened the lime bricks were unloaded almost in a whole state, were ground under stones, screened, and carried to the works pure and free from ash or dirt. The mortar was made from one part of ground lime and one part of clear, sharp sand. This mortar was used in all the well foundations of the bridge up to the level of low water; and as a proof of its quality it was stated that it was easier to break the work as a mass than to separate it at the joints or beds. Above the level of low water the mortar was composed of white hill lime, and sorkhee, or crushed brickbats, in equal proportions, as it was found that the lime from the calcareous clay lost the greater part of its cohesion when used in work exposed to the vicissitudes of the atmosphere—whether this arose from the frequent changes from dryness to humidity, or from heat to cold, was not ascertained.

Time Occupied.—The well sinking for the foundations of the piers and the abutments of this bridge was completed in little more than two years, which, without deducting any time for building up the brick work, or for that unavoidably lost by the rise in the river during rains, gave an average rate of 159 ft. per month. The time occupied in the building of the steining of the wells, erecting, taking down, and reërecting scaffolding and staging for sand-pump, weighting the wells, &c., was equal to that employed in sinking. This would give the rate of sinking as a little over 300 ft. per month. If cast-iron cylinders had been used, the work could have been performed much more quickly, as the portions of the cylinders could have been put together more rapidly, and owing to the slight bearing surface exposed by the thickness of the iron, compared to the breadth of the brick work in the walls of the well. The total weight of the foundations and of the iron girder superstructure on each well was 420 tons, and the area of the bottom of each well was 117 ft., so that the weight was less than 4 tons per square foot.

The Sand Pump.—The novelty in the sinking of the wells of this bridge was in the use of the sand pump. This was described to consist of a wrought-iron cylinder having a pump riveted to it at the top, in which was a piston fitting loosely, and pierced with small holes to allow of the escape of water. The piston rod terminated in an eye at the upper end, to which a chain could be attached. The bottom of the cylinder was movable, and in the center there was an upright suction pipe, projecting outwards for a distance equal to its own diameter, and inwards nearly to the top of the cylinder. When the pump was lowered to the bottom of the well, the chain attached to the piston rod was worked up and down like a ringing engine. In this way water was first drawn through the upright pipe, followed by sand or other material, which fell over the pipe into the cylinder. This operation was continued until the cylinder was quite full, which was known by the piston working stiffly, when the machine was raised to the surface; the bottom of the cylinder was then detached, with the column of sand resting on it, and another cylinder bottom which had been cleared of its sand was substituted. The number of men employed at each well was fourteen, nine working the chain, two clearing away the stuff brought up by the pump, one in charge of a steam hoist, one breaking firewood, and an overseer. The average rate of sinking, including contingencies, was about 6 ft. in eight hours. This rate was extraordinary when compared with the old system of the "jham" and diver, and would, it was believed, materially reduce the expense of bridge work in India.

Milroy's Excavating Apparatus.—Mr. Milroy believed that for the purpose of sinking cylinders, the great desideratum hitherto had been some method of excavating the earth from the interior without at the same time having to take out the water, and to keep it out during the operations. This object seemed to the author to have been attained by a machine of his invention, which was used in the construction of the bridge over the river Clyde, for the Glasgow (City) Union Railway, to which Mr. Fowler and Mr. Blair were the engineers.

The excavating apparatus, commonly called the "excavator," was thus described: It consisted of a horizontal frame of iron, with an outside rim 9 in. in height, to which radiated, like the spokes of a wheel, T-irons from a small cast-iron ring in the center. To the bottom of the outside rim were hinged eight heavy iron spades, which, when drawn in, fitted closely, with their points pressing against the inner ring. The hinges of the spades were so constructed as to prevent them from turning back beyond the perpendicular. The whole apparatus was very strongly made, and it formed, when closed, a nearly water-tight tray. When the machine was descending the spades were allowed to hang vertically, and they were forced into the ground by the aid of two chains fastened to the top of upright arms on opposite sides of the excavator, then passed down the cylinder, under a pulley, up between two leaders, and over another pulley, the end of each chain being wound round the large axle of the capstan, or drum, on the landing stage. These chains were calculated, when tightened, to keep the machine down, whilst the spades were being drawn in through the crowd, and up to the frame. This was effected by a second set of chains, all of equal length, and each fastened at one end to the inside of a spade, and at the other end to the end of a main chain, by which the machine was raised to the surface, with the earth it contained, by means of a steam hoist. In order to enable an opinion to be formed of the capabilities of the excavator, it was mentioned that the progress of the excavation, and the corresponding subsidence of the cylinder, reached from about 12 ft. to 20 ft. per day of ten hours, inclusive of the time employed in adding fresh lengths of cylinder, putting on weights, &c. When there had been little interruption for any of these purposes, it had amounted to 25 ft. in the ten hours, and then the average quantity of sand brought up at each lift was 21 cubic feet, and the total quantity during the day was found, by measurement, to be 70 cubic yards. Twelve men in all were employed, viz: one engineer, one stoker, six men working the drums, three attending to the loading and discharging of the excavator, and one man wheeling away the materials.

In conclusion, the following advantages were claimed for this apparatus: First, that it was perfectly independent of water, which was allowed to remain in the pit or cylinder until the excavation was completed; secondly, that it could be used, and was equally effective, at any depth, without sensible difference in the cost of working; thirdly, that its rate, both of sinking and of excavating, was higher than had yet been attained by any other method; and lastly, that it was not liable to get out of order, whilst its action was always in the same perpendicular line, and the expense attending its working was comparatively trifling, as skilled workmen were not required.

Chimney Sweeping "Engineering" in Amsterdam.—There has recently been formed in Amsterdam, with the Royal approbation, a nondescript association with the title, "*Amsterdam Soot Company.*" The director has the title, "Royal Chimney Engineer;" the managing agent is a distinguished advocate of that city, and the commissioners designated by the government are, an inspector of public works, a great diamond merchant, already president of one industrial association, and an architectural engineer, who is also a manufacturer. The company has for its business the sweeping of chimneys and trade in soot.—*Annales du Génie Civil.*

TEN-WHEELED FREIGHT ENGINE—PENNSYLVANIA RAILWAY.—One of these engines, as designed by Mr. J. B. Collins, Mechanical Engineer to the Company, is fully illustrated in "Engineering," March 5th. The intention in the design was to embody all improvements developed by experience, and to omit all superfluities of construction. In the finish of the engines there is no attempt at ornamentation; there are no brass bands about the boiler, and there are no brass accessories, except the bell and whistle. The painting is plain, and no scroll-work or pictures are introduced. The object sought, in fact, has been to make a plain serviceable engine, without any unnecessary ornamentation. The principal dimensions are as follows:

	ft.	in.
Cylinders.		
Diameter	1	6
Stroke	1	10
Distance apart from center to center	6	9
Length of ports	1	4
Width of steam ports	0	1¼
Width of exhaust ports	0	2½
Width of bars	0	1
Distance from center of cylinder to valve face	1	3⅝
Lap of valves	0	0¾
Travel of valves in full gear	0	5
Wheels.		
Diameter of coupled wheels	4	7
Diameter of bogie wheels	2	4
Distance between center of bogie wheels	5	8
Distance from center of bogie to center of 1st pair of coupled wheels	8	5
Distance between centers of 1st and 2d pairs of coupled wheels	5	0
Distance between centers of 2d and 3d pairs of coupled wheels	7	5
Total wheel base	23	8
Boiler.		
Diameter of barrel outside largest plate	4	2
Length of barrel	11	11
Length of fire box casing	5	9¼

The four-wheeled bogie under the front end of the engine is of the ordinary pattern, with a swing beam, and the front pair of coupled wheels has tyres without flanges. The bogie is fitted with the usual chilled disc wheels, and the coupled wheels are of cast-iron with hollow spokes and rim. The connecting rods take hold of the crank pins on the center pair of coupled wheels, and the eccentric rods are cranked so as to pass respectively above and below the front pair of coupled wheels to the links. The valve faces are situated above the cylinders, and the valves are worked through the intervention of rocking shafts, as is usual in American engines.

LIGHT RAILWAY ROLLING STOCK.

From "The Engineer."

That railways do not pay a fair profit on the sums invested in their construction is a truth fully recognized by the modern capitalist. This truth, so important in its bearing on the development of the resources of the country, has been carefully investigated by engineers and financialists alike, and, as a result of this investigation, two general propositions have been laid down. The first is, that very large sums have been in some cases necessarily, in other cases unnecessarily, wasted in unproductive work, such as law expenses, the construction of palatial termini, the reduction of lines to a dead, or nearly dead level, by embankments and cuttings, etc.; the second proposition is, that railways do not pay because they are worked on too expensive a system. If we may be allowed the expression, according to one party the statics of our railway system are to blame; according to the other the dynamics of that system are in fault. It forms no part of our purpose now to investigate questions relating to the statics of the railway system. The railways are there, with all their faults or excellencies, and cannot be altered. We must make the best of them. We propose here to consider the bearing of some of the questions connected with the dynamics of railways, that is to say, the system on which passengers and light goods are conveyed from place to place; but we wish it to be particularly understood that nothing which we may advance in favor of the use of light engines is intended to apply to the working of heavy goods or mineral trains. These can only be hauled by engines of great power; and the heaviest goods locomotives bear a comparatively reasonable proportion to the weight of the loads drawn by them—a condition favorable to economy, which has no existence in the case of passenger and other light traffic.

We are indebted to Capt. Huish's "Reports on Railway Plant," for the following statements as to the augmentation in the weight of railway rolling stock, which took place between 1831, the date at which the reports commenced, and 1848. The reports refer to what is now known as the London and North-Western system. In 1831 the average weight of the engines on the Liverpool and Manchester, and London and Birmingham Railways, was seven tons. In 1848 it was more than twice as much, being

18 tons 13 cwt. The heaviest engine in use on these lines, in the first mentioned year, was seven tons; in 1848 it was 37 tons. The weight of the carriages increased in the same period from a maximum of 3 tons 10 cwt. to 4 tons 6 cwt., and the average speed of the passenger trains had increased from 17 miles per hour to 30 miles per hour. What took place on the North-Western system accurately shows what took place through the length and breadth of the kingdom—*ex uno disce omnes*. There is not, so far as we are aware, any compendious statement in existence which will show the amount of augmentation between 1848 and 1868, but there is good reason to believe that it is very considerable. Engines weighing less than 20 tons full, are now the exception; and the average weight of all the engines working important lines in England must exceed 23 tons. The weight of carriages has also gone up, 5, 7, and even 9 tons being no uncommon weight for ordinary carriages, while on the Metropolitan Railway, carriages are used which weigh 16 tons. It does not appear that the carrying capacity of these carriages has undergone a corresponding increase. Additional strength, especially in the under frames, has been introduced, because heavy engines knock light carriages to pieces; but it does not appear that any other very valid reason for the increase of weight has been adduced, save perhaps one, viz., the modern carriages are rather more roomy and commodious than those used 20 years ago.

There is no room to doubt that the dead weight of engines was first increased in order to get more power; and had it been possible to work these heavier engines with carriages of the same weight as those employed in the earlier days of the railway system, all might have been well; twenty tons or so would have remained about the weight of the heaviest class of locomotives employed in conveying passengers; but the increased dimensions of the engines rendered a corresponding increase in the strength and weight of the vehicles drawn a necessity. The augmentation reacted on the engines, and so weight increased daily and hourly, till a new element was introduced which rendered further augmentation all but an impossibility. This new element was the stability of the permanent way. The roads could not sustain heavier loads, and therefore heavier loads were not put on them. It must not be forgotten that at one time there was a species of mania among locomotive superintendents for big engines. It was, in the first place, a very pleasant thing to be able to boast that you had bigger engines than your neighbors, just as it is a pleasant thing to have the fattest ox at a show, or the finest house in a street. In the second place, it was pleasant to know that when you stood on the foot-plate, you had beneath you a machine capable of whisking the train behind it at almost any pace you pleased. Big engines were, in a sense, luxuries, and they were paid for at a price which railway companies could not afford. Probably the first blow that the big engine craze ever received was the failure of the "Liverpool," on the London and North-Western Railway. This engine was built by Mr. Crampton, especially to compete with the large engines which Brunel, who idolized the Big, patronized on the Great Western. The "Liverpool" had 18 in. cylinders, 24 in. stroke, 2,290 ft. of heating surface, two 8 ft. driving wheels, six 4 ft. carrying wheels, an 18 ft. 6 in. wheel base, and weighed full 35 tons. The tender weighed 21 tons. Total weight, 56 tons. After working the express traffic between London and Wolverton for some time, it was found that the permanent way began to give out, and so the engine was withdrawn from active service.

After enduring for many years, the passion for large and heavy engines appears to be dying out; and engineers who not long ago regarded heavy engines as the *summum bonum* of locomotive superintendial happiness, are now quite prepared to listen to reason, to investigate patiently, and even to believe that it may be quite possible to work, if not all, still a considerable portion of the ordinary passenger traffic of our railways on a system which completely ignores heavy engines and heavy rolling stock. There is not wanting evidence that a species of revulsion of feeling is setting in, and not the least hopeful symptom is that already we hear rumors of the formation of a company, having on its board of direction some of the ablest engineers of the day, and specially called into existence to test cautiously and tentatively the merits, advantages, and disadvantages of the light rolling-stock system. What this system is we propose to tell such of our readers as are not familiar with its characteristics; and we shall further add some facts, now matters of history, which will show that the prospects of success are enormous; so enormous that we cannot account for the neglect of the system during past years on any other hypothesis than the existence of an all but universal mania for big engines, to which we have already alluded.

According to the advocates of the light rolling stock system, heavy engines are required only because the trains are heavy. Keep down train weight, and engine weight is decreased as a matter of course. This object they propose to effect by the use of combined carriages and engines. Whether this arrangement is or is not the best that can be adopted, we are not about to decide. It illustrates very clearly the principles of the light rolling stock system, and, in so far it answers our purpose at the moment. We shall have something to say to its mechanical fitness for the intended purpose hereafter. In this arrangement the weight of the engine is very small comparatively, and the load it is to haul is also light. It is urged against light engines that they lack adhesion. Quite so; but adhesion is a comparative term after all. That one of the new engines will not possess enough adhesion to haul a 300 ton train is quite true: but it is not wanted to haul 300 ton trains, or even 100 ton trains; and if it can be shown that it possesses adhesion enough to haul the greatest load which it is intended to haul, then it has adhesion enough. Now by making some of the wheels of the vehicle as a whole, not only carry all the engine, but a part of the load as well, it is apparent that the engine must be better off for adhesion, *cæteris paribus*, than any ordinary tender engine—better off, indeed, than any tank engine. There is no room whatever to doubt that the proposed carriage will do what it professes to do, at least so far as adhesion is concerned.

The entire weight of a combined passenger carriage and engine need not exceed sixteen tons, to convey 90 passengers, weighing six and a half tons. There is not at this moment a railway in the kingdom conveying the same number of passengers which does not put in motion a dead weight of 34 tons, or more than double that of the combined carriage. In one case 2.461 tons of dead weight are employed in the conveyance of each ton of passengers; in the other, the dead weight is to the paying load as 5.23 to one. Nor is this all. The sixteen tons of the combined carriage may be, and should be, carried on eight wheels, and no pair of wheels should carry more than five tons. If an ordinary locomotive is used, the smallest weight on at least two pairs of wheels must be double that on the two pairs drawing the combined carriage, for as the load is more than double, the adhesion must be more than double, and the adhesion is as the weight—unless, indeed, the locomotive is to have less adhesion than the combined carriage. And if it is admitted that it can do with less, then the argument that the combined carriage will not have adhesion enough falls to the ground. But it may be shown that the injury done to permanent way will be as great by one pair of heavily loaded wheels as by four or five pairs—that is to say, if in a train 100 wheels are loaded with but two tons each, while the single drivers of the engine are loaded with five tons each, then the road must be strong enough to carry not the light but the heavy load. It follows that rails weighing 45 lb. to the yard would carry the combined engine and carriages as well as 60 lb. or 70 lb. would carry trains worked on the ordinary system. Or that if existing track is retained, it will, if the rails are of good quality, cost little or nothing in repairs, the road being practically indestructible under the assumed conditions of load. It follows, therefore, that the expense of road maintenance may be enormously reduced by the adoption of the combined system. We shall show in a moment how great a saving may be effected in running expenses.

"But," it will be urged, no doubt, "if the light system is so good, why has it not come into use long since?" Now, on this point we are not prepared to speak fully. We believe we may go so far, however, as to say that its non-adoption has resulted from causes which have had nothing to do with questions of mechanical science, and we shall not further refer to them. The best answer that can be brought to all cavilers lies in facts, and we shall, for convenience, first sum up all the objections which, so far as we are aware, have been brought against the combined carriage system, and then proceed to consider them in connection with facts.

1st. Steam carriages must lack adhesion.

2d. They must be slow, because their boilers must be small.

3d. They cannot be competent to deal with exceptional traffic, as, for instance, on market days in country districts.

Now, it so happens that every one of these points was raised and settled long since. It is a great mistake to suppose that we have been theorizing all this while; on the contrary, every statement we have made in favor of the light rolling stock system, and the whole purport of this article, is borne out by the practical results obtained from the actual use of combined carriages and engines years ago.

Some twenty years ago Mr. Gregory had a combined carriage and engine from Mr. W. B. Adams to work the Tiverton branch of the Bristol and Exeter Railway. This steam carriage was christened the Fairfield. The machinery and carriage body were on one frame, 40 ft. over all, hung on six wheels; the two leading wheels, 4 ft. 6 in. in diameter, being the drivers. The wheel base was 28 ft. long, and peculiar provisions were introduced to let the machine get round curves. The cylinders were 8 in. diameter, 12 in. stroke. The boiler, of the ordinary type, was 7 ft. 7 in. long in the barrel, and 2 ft. 6 in. diameter. It contained 115 tubes $1\frac{1}{2}$ in. by 8 ft. The fire-box was 2 ft. 6 in. long by 2 ft. 3 in. wide, by 4 ft. high. The heating surface in the box was 37 ft., in the tubes 325 ft. The carriage carried fifty-eight passengers.

Now let us see how far the performance of this steam carriage justified the objections urged against the system. First as regards want of adhesion. We find that the Tiverton branch was five miles long, and had a gradient of 1 in 86; the fact that this was regularly worked in all weathers, is proof that the adhesion was sufficient. Next, as to speed. The Fairfield ran from Exeter to Bristol, 76 miles, with an extra load behind her weighing ten tons, equal, say, to 140 passengers in all, in three hours 37 minutes. Of this time 58 minutes were spent stopping at twelve stations, leaving her regular pace 28 miles an hour. The maximum speed attained on this trip was 47 miles an hour. So much for speed. Now for capacity. The Fairfield took as much as 31 tons—that is to say, three other carriages loaded, up the Tiverton gradient of 1 in 86, doing the five miles in eleven minutes, or at the rate of 27 miles per hour. This surely demonstrates the practicability of attaching more carriages when necessary, and therefore of rendering steam carriages quite competent to the discharge of abnormal duties. The consumption of fuel on regular work was 8.7 lb. of coke per mile. After working the Tiverton branch for some time the Fairfield was put on the line from Clevedon to Yatton; on this road her regular speed was 24 miles per hour, she ran sixteen trips, or 64 miles per day, and used, in doing so, $397\frac{1}{2}$ gallons of water, and the total cost of running, exclusive of repairs, was but $3\frac{1}{2}$d. per mile.

The results obtained from the Fairfield were eminently satisfactory—satisfactory enough, we think, to justify the favorable opinions we have expressed regarding the system; but we have still more conclusive evidence to urge in its favor. Mr. Samuels designed a carriage built by Mr. Adams, and called the Enfield, which was put to work on the Great Eastern Railway. We are indebted for the following facts relating to the Enfield to a paper read by Mr. Samuels before the Institution of Mechanical Engineers:

The Enfield had 8 in. cylinders and 12 in. stroke; driving wheels 5 ft. diameter; distance between centers, 20 ft.; width of framing, 8 ft. 6 in. The boiler was of the ordinary locomotive construction, 5 ft. long by 2 ft. 6 in. diameter. The fire box was 2 ft. $10\frac{1}{2}$ in. by 2 ft. 6 in. There were 115 tubes of $1\frac{1}{2}$ in. diameter, and 5 ft. 3 in. in length, giving a total of 230 ft. heating surface in the tube. The area of the fire box was 25 ft., giving a total heating surface of 255 ft. The weight of this steam carriage was 15 tons 7 cwt. in working trim. The engine and carriage being combined, it is evident that the weight on the driving wheels was increased by the load carried, and that this weight increased in the same ratio as the load required to be taken. The extreme distance between the centers of the leading and trailing wheels being 20 ft., accounts for the steadiness of this machine; there was, indeed, no perceptible oscillation when traveling at the highest speed, and this verifies the observation, "that the steadiness of an engine depends not on the position of the driving wheel, but upon the length of the rectangle covered by the wheels." This engine, at the same time, daily traversed curves of five or six chains radius. The Enfield steam carriage was originally intended to convey 84 passengers, but as it was found that when she was put on as an express train the passengers increased in number, a North Woolwich carriage was attached capable of conveying 116 passengers, and also a guard's brake-van, making provision altogether for 150 passengers, which was her regular train, taken at a speed of 37 miles per hour.

The following return shows the miles run and coke consumed by this engine during the seven and a half months' regular working, from January 29th to Sept. 9th, 1849:

Total miles run..........................	14,021
Hours, running time	705
Hours, standing time....................	1,457
Total hours in steam	2,162
Cwt. of coke consumed in running	743
Cwt. of coke consumed in standing	408
Cwt. of coke consumed in getting up steam,	286
Total cwt. of coke consumed.............	1,437
Pounds per mile ave. consumption of coke,	11.48

The Enfield was in steam fifteen hours per day, the fire being lighted about six in the morning and drawn at ten o'clock at night. But of these fifteen hours it appears, by the return, that she was engaged running only five hours, the remaining ten being employed standing in the siding. It was found by experiment that the quantity of coke consumed standing was 32 lb. per hour; and after deducting this and the quantity consumed getting up steam, it will appear that the actual consumption of coke running was under six pounds per mile. It must also be particularly borne in mind that this consumption of coke included the total goods and coal traffic on the branch, amounting to 1,410 tons, viz., 169 tons of goods and 1,241 tons of coal. The Enfield steam carriage worked the 10 A. M. passenger train from London to Ely, on 14th June, 1849, a distance of 72 miles, taking behind her three of the ordinary carriages and two horse-boxes; she arrived at Ely eight minutes before time, and the total consumption of fuel, including the getting up steam, was found to be 8¾ lb. per mile. The tubes of the boiler were only 5 ft. 3 in. in length, and the economy of fuel is consequently scarcely at the maximum. Mr. Gregory expressed, in the paper in question, as the result of his experience, the conviction that, for express purposes, and for the larger portion of the branch traffic on railways, the light steam carriage is the best adapted and most economical machine, both as to first cost, compared with the work done, and in working expenses. The repairs of the permanent way were also very much reduced, as may be easily imagined. On the Eastern Counties Railway, in 1849, an engine and tender of, say, 30 tons, a brake-van, a first-class carriage, and three third-class carriages, conveying 120 passengers, made a total weight of 59 tons, and the consumption of coke was, on the average, 34 lb. per mile. A steam carriage weighing only seventeen tons will transport the same number of passengers at from 7 lb. to 8 lb. per mile when the best proportions are attained.

It is unnecessary, we think, to prolong this article by adding further arguments in favor of the light rolling stock system. We shall, in another impression, consider the nature of the mechanical problems to be solved by the designers of steam railway carriages, and the best methods of solution.

STEEL HEADED RAILS.

In 1866 Messrs. John A. Griswold & Co., of Troy, sent 500 tons of steel headed rails, in lots of 10 to 100 tons, to some dozen different railway companies. The steel surface was about ⅝ in. thick when finished; the rail was a pear-headed 56 lb. pattern, the stem being, as it proved, too light for very heavy engines. Under a yielding iron head, the web had proved strong enough. Under the very heavy engines of the New York Central and Michigan Southern, some of these rails failed in the stem, but the heads rarely became loosened. The wear was, however, in the worst cases, very much better than of iron, and the greater number of the rails are still in use on these lines, although placed where they endure constant switching and unusual wear. On some lines, where the machinery is somewhat lighter, these rails are all in excellent condition. Some on the Hudson River road, between Albany and Troy, show hardly any deterioration. The report of the Eastern Railway (Mass.), for 1868, says of them: "We have had 25 tons of iron rails with steel heads, in use as an experiment, in our main track for upwards of two years, and so far with the most satisfactory results." The Superintendent of the Boston and Providence Railroad, says of some of the same lot of rails: "I take pleasure in saying that a lot of steel-headed rails, furnished by John A. Griswold & Co., in 1866, are wearing equal to the best English (steel) rails; indeed there is no difference. These rails are laid on one of the most exposed places on this road." On the whole, this steel-headed rail has proved itself equal to about three of the best iron rails.

The heads of these rails were made from some of the first Bessemer steel produced at Troy, and were rolled into slabs deeply grooved on the under side, where they were to be joined to the iron pile. The weld, or the weld and the dovetail together, made a much more perfect union between the head and the rest of the rail, than is usually made in iron. The three years practical test, and numerous tests by the trip-hammer, have shown the union to be sufficient, and nearly uniform for the whole lot. With a heavy, strong iron body, such steel-headed rails should wear, for some years, as well as all steel, but of course they would not be as stiff, and when the head was worn very thin, it would doubtless come off. The practicability of making a good steel-headed rail, by this method, is certainly proved.

Another kind of steel-headed rail is being produced by Mr. Coxe, at the Reading Railway Company's mill. The cut, Fig. 1, shows the method of laying up the pile (9 in.), the shaded parts being separate small bars of low cast steel, made at the William Butcher Steel Works, Philadelphia. Fig. 2 (full size) shows the steel as it appears in the finished head.

Fig. 1.

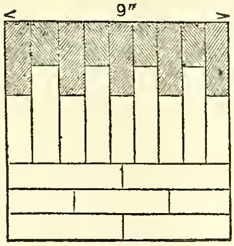
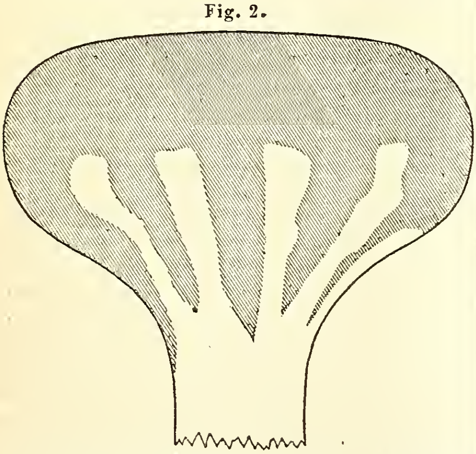


Fig. 2.



The welding appears very good, although the head cannot be as homogeneous as a solid slab. With some of the piles, borax, fireclay, and sand were used as flux; with others, the Hindermeyer flux, which was quite satisfactory. Some 20 tons of these rails have been laid in one of the hardest places in the Reading track, which will soon determine their value.

THE HISTORY OF GUN-COTTON.

THE EARLY MANUFACTURE—ITS DANGER AND ABANDONMENT—LENK'S IMPROVEMENTS—NEW DIFFICULTIES—THE MANUFACTURE IN ENGLAND—ABEL'S IMPROVEMENTS—PRESENT PROCESS AND RESULTS.

Compiled from the London "Times."

In the year 1846 Professor Schönbein, of Basle, announced that he had discovered a substance possessing all the useful qualities of gunpower without the defects. Gunpowder is dirty, rather dangerous to manufacture, and leaves behind it when exploded both a considerable quantity of solid matter, fouling the piece within which it has been consumed, and volumes of stifling smoke. The invention made its way into popularity with great rapidity, for what can be more desirable than an explosive material of great strength in the form of a soft, clean substance that gives no smoke in its combustion, and leaves no traces behind? The idea of gun-cotton was not entirely new. Braconnet in 1833, and Pelouze in 1838, had produced a material called xyloidine, very similar in its nature to gun-cotton. Pelouze had even proposed its employment for artillery purposes, but the subject had never attracted much attention till Schönbein exhibited the substance itself to the British Association at Southampton in 1846 In the same year he proposed it for trial in France, Prussia and Austria. A general enthusiasm arose; and, while Messrs. Hall, of Faversham, began to manufacture it in England, foreign governments seized upon the idea, and began to carry it vigorously forward.

But if its popularity arose and spread rapidly, so did the reaction against it. Terrible explosions occurred in factories and magazines—not in one country, but in all. In England three men who were making gun-cotton rockets were killed on the 24th of June, 1847; and on the 14th of July such a fearful explosion happened at Messrs. Hall's factory that gun-cotton became as much dreaded as it had been welcomed before. The two buildings in which the manufacture was in progress had walls eighteen feet thick, and were separated by a huge mound of earth forty feet high. Yet the echoes of the first frightful roar had not been given back before the second building blew up. Late discoveries seem to throw some light upon this phenomenon, which has often been noted as occurring even in gunpowder explosions. A distance of two or three hundred yards has been found insufficient to break this terrible sympathy—for sympathy it probably is. At Messrs. Hall's works twenty-one persons were instantly killed, and sixteen suffering wretches lay mangled or burnt upon the ground. The manufacturers would have no more to do with so deadly a material. No one could tell how either of the explosions had occurred. A dread mystery hung over the event, and Messrs. Hall set men to dig a deep pit, into which they threw all the gun-cotton they had made, right thankful to see it interred alive. And alive it was still. Sixteen years afterwards some of it was dug up for experiment. The rains had filtered through it. The earth, greatest of all chemists, had worked what it could upon the soft white mass, but its nature remained the same, and its force was but little abated. It is not necessary to say that gunpowder would, under such conditions, have melted into a black paste, and, gradually parting with its saltpeter, have become perfectly innocuous. The French government and the German Confederation were almost equally unfortunate ; and the worst feature was that no amount of care seemed sufficient to preserve gun-cotton from ignition. The ugly phrase "spontaneous combustion" was whispered about, and every report was unfavorable to the new explosive.

Among the officers composing the committee assembled from the different armies of the German Federation was a certain Austrian captain of artillery, called the Baron von Lenk. Agreeing with his coadjutors that gun-cotton, in its actual state, was not suitable for military purposes, he yet believed that it could be made so. Encouraged by Count Degenfeld, he prosecuted his experiments, and found out how to render it safer. He also tried to control its action; for one of the great faults of the old gun-cotton was its excessive rapidity of inflammation, and consequently destructive effect upon the gun in which it was fired. The safety was gained by a more complete conversion of the original material into gun-cotton, and its subsequent purification from all traces of uncombined acid, as far as was possible, in his method of manufacture. The regulation of the action was obtained, so far as it was obtained at all, by using skeins of twisted cotton in the first instance, and then winding them round wood, twisting them into ropes, or compressing them into comparatively solid masses. Some success was attained, and the Austrian government again took up the question. When an army of observation was placed in Galicia during the Crimean war, four batteries of eight guns each were provided with gun-cotton charges. There was no opportunity of trying them in battle ; but experiments showed that the new material was uncertain in its action and destructive to the guns. Some of the charges even ignited during the process of loading. Artillery officers almost unanimously rejected gun-cotton; and it would have been forgotten, but that none of its objectionable properties seemed to hinder its employment for mining purposes, while the suddenness of its effects rendered it peculiarly well adapted for blasting rocks and submarine explosions. So the engineers received it as it fell from the hands of the artillery, and have never since entirely rejected it. They had stores of it in Venice and the Quadrilateral during the war of 1859 ; and even the artillery, being in want of something that could be called new to oppose to the French rifled guns, prepared gun-cotton batteries in Vienna, which were, characteristically, just ready for service when peace was concluded at Villafranca. Scarcely had a few rifled guns been made on the French system, when it was found that they would not do. Count Degenfeld was appointed Minister of War, and again brought gun-cotton forward for artillery. An ingenious system of rifling was devised. and tried with gun-cotton. The results were good enough to warrant the Minister in ordering thirty batteries (240 guns) to be prepared and equipped in the same manner. Some of the European nations which had dropped the subject since 1847, England being one of them, sent officers to study the details, and learn Lenk's system of making gun-cotton. But just then came reports of unlooked-for burstings of shells and mining charges in Italy or at Vienna, and, finally, the blowing up of a magazine at Simmering, near Vienna, where gunpowder and gun-cotton were stored together. The old mystery hung over the occurrence. No fire had been near the place, as well as could be learnt. It was enough. The Austrian artillery had burnt their fingers too often; they would have no more of this soft, white, treacherous substance, which promised so fairly only to betray. It fell completely out of favor, and nothing has been done with it since in Austria, except for mining purposes and torpedoes.

But the British Association had taken up the matter again in 1862, under the advice of General Sabine, R. A., President of the Royal Society. A committee was appointed, their report was read in 1863, and at last the English government appointed a committee to investigate the whole subject. According to British usage, they began at the beginning, and worked doggedly on through all previous experiments, leaving nothing unproved. They had just cleared the subject from most of the fog that obscured it, and the light was beginning to shine pretty clearly, when, again according to British usage, the committee was suddenly dissolved. Fortunately, Mr. Abel, F. R. S., chemist to the War Department, had become a convert to the possibility of eventually finding a substitute for gunpowder, either in gun-cotton or some analogous substance. His researches have already carried the subject far beyond any point previously attained, and the progress made has been so considerable that gun-cotton may now be considered as quite fit for sporting purposes, and on the way to become so for rifled small arms, perhaps even for field artillery. It appeared as if chemists could in nowise satisfy themselves as to the value of the material until they had put a hard name to it. As long as it was only gun-cotton it made no progress. It languished even as pyroxylin, but has moved steadily forward ever since it became tri-nitro-cellulose, a rich name and comfortable to the mind.

It was, therefore, not to see gun-cotton made and tried, but to witness the manufacture and investigate the properties of tri-nitro-cellulose that a party of scientific gentlemen and military officers, French and English, recently went down to Stowmarket. Mr. Abel's improvements have been adopted by Messrs. Prentice, and at their works alone can now be studied the latest forms which this material has put on.* The Austrian manufacture stopped at the point where the cotton was supplied in the form of skeins, which were dipped in a mixture of nitric and sulphuric acid, then placed in jars to soak thoroughly, then half dried in a centrifugal apparatus, and afterwards washed thoroughly and long by hand and in running streams until no free acid could be detected. For small arms cartridges a hollow plaited rope was then made of it, cut into lengths, and arranged round little wooden spindles, the ends of which penetrated the bases of their bullets and held fast there. When first Messrs. Prentice commenced their manufacture they were under the advice of Baron von Lenk, and followed the Austrian method exactly. Soon they found the rope plait was inconveniently long. They tried a solid pope, but it inflamed too suddenly and strained the gun. Then they tried a solid rope of mixed gun-cotton and common cotton. This was not so dangerous, but its action was not always the same. They tried also what may be called gun blotting-paper, and rolled it up into cylinders for cartridges, but they have now exclusively adopted Mr. Abel's newer methods, which have the two advantages of rendering the gun-cotton perfectly safe and almost perfectly manageable—safe because the great thing to be avoided is a mass of cotton, either imperfectly converted or containing free acid. Cotton, like hair in its ordinary state, is made up of a vast number of small tubes, which all have the power of taking in liquid by capillary attraction, and retaining it in spite of all washing. If there is any free acid in the gun-cotton it has many opportunities for combining chemically with other substances, and so setting up heat which accumulates, and may at last fire a portion of the mass. Mr. Abel obviates this by tearing the cotton into fragments, making it, in fact, into pulp. The process of making gun-cotton at Stowmarket is thus carried on :—

Rough waste cotton. no matter how short the fiber, is cleaned thoroughly, dried, and dipped into a mixture of three parts sulphuric acid to one of nitric. If the acids were weak, the cotton would dissolve. With the strong acids used a combination of the nitric acid and cotton ensues, while the sulphuric acid takes up the water left behind by the nitric acid and so keeps the latter always strong. There is a row of small tanks fed with acids through pipes from a reservoir. Into each of the tanks one pound of cotton is dipped, care being taken to immerse it all completely. It is then taken out and laid upon a grating over the tank to drain, and thoroughly squeezed by iron paddles. Twenty minutes suffice for this operation. The converted cotton now goes into jars, which stand in water to keep them cool, for much heat is

* The Messrs. Prentice commenced the manufacture of gun-cotton under Baron von Lenk's patents in 1863. We had an opportunity to witness the first experiments made by them, which, together with many other experiments and facts of interest concerning gun-cotton, are very fully considered in the appendix to "Ordnance and Armor."—*Ed. V. N's. Magazine.*

developed in the combination. After soaking here for many hours, the cotton is placed in a revolving drum with small holes in its exterior. It whirls rapidly round, and discharges most of the spare acid by its centrifugal force. Then comes a very important process—the washing. First the cotton is thrown into a fall of water, and a man watches to prevent any of it escaping instantaneous immersion, otherwise the acid and the water would set up an action strong enough to burn some of the cotton, or, at least damage it. After thorough washing in a tank under the waterfall the material is placed in a vat to steep in water for twenty-four hours; then it goes to a second and a third, and so on for a week. By this time no acid is perceptible. The cotton is then placed in a mill like that used in paper-making. The water used to make the pulp is slightly alkaline, in order to take up the last traces of acid. The next operation is drying again in a centrifugal machine. There has now been produced a gun-cotton pulp, which has only to be pressed into the shapes most convenient for its intended purpose. The most common forms are those intended for fowling-pieces and blasting. Another invention has lately been introduced to render the cartridges impervious to damp. There are 30 grains of cotton to a gun of No. 12 bore. One grain of india-rubber dissolved in 30 grains of spirit is then used to saturate the pressed gun-cotton. After drying, the spirit evaporates, and the caouchouc remains throughout the mass, completely preserving every particle from damp, though gun-cotton does not deteriorate by damp so long as it be dried again before firing. Almost everything that is made of gun-cotton has a hole through it to facilitate combustion. The pulp is first pressed in a very wet state, and then pressed yet smaller before drying. It is finally dried, and put in boxes for use. The pulp and various shapes into which it is pressed are Mr. Abel's inventions.

Such is the manufacture of gun-cotton. Some of its properties are most curious, and really deserve to be called sympathetic. For instance—take a loosely-twisted thread of gun-cotton, and lay it on a flat table, carefully drawing out a few filaments at one end, so as to form a point. Light a small piece of wood, a match if you will, but blow it out as soon as the wood is well inflamed. Approach the spark that remains delicately to the extended filaments. They meet it and begin to burn. But how? Very far from explosively. The whole thread smoulders away like touch-paper so long as no wind blows upon it. But blow the flame the least towards the rest of the thread, or even bring a flat surface close to it so as to push the heated gas for one moment back upon the thread, and the whole goes off in one flash in the ordinary way. Light it with the flame of a match, the whole flashes off at once. Go one step farther, and ignite it by a little detonating arrangement, the gun-cotton sympathizes again and actually detonates. Since this curious property was discovered, it has been found to apply to gunpowder in a more limited form; and here have we not the long-sought clue to the sympathetic explosion of one magazine after another even when at considerable distances apart? Neither a layer of air, nor water, nor even plaster of Paris, will save gun-cotton from detonating if there be an explosion of the same character near it. Here is a strange physical property which will be of the utmost value in mining. It is the sudden and violent effect of nitro-glycerine without its character of treachery to its friends. The miner has in his charge of gun-cotton two perfectly different physical forces stored up. He can call either of them into life at his will. Let him light his piece of prepared rope with any ordinary flame, even the explosion of gunpowder—the gun-cotton will give just such a rending strain as gunpowder gives—rather more rapid, but of the same nature. Place a small detonating tube inside your rope or leaning against it, ignite this, and the gun-cotton will explode with the same rapid, active, intensely local explosion, shattering to atoms all that is within reach. The smouldering form of burning is as yet too delicate to be made practical use of. The mildly explosive form is adapted for guns, the rapid shattering for any purpose where great local effect is to be produced, such as shattering rocks into small pieces, charges for shells, blowing down palisades, and generally breaking anything into pieces.

Illustrations of the two latter forms of explosion were given abundantly recently (Jan. 22). After seeing the processes of manufacture, the visitors went to the shooting-ground and not only saw some practice, but ascertained personally the comparative effect of gunpowder and gun-cotton in a fowling-piece with small shot. The penetrative effect was about equal. The gun-cotton cartridges threw closer, and in a very marked degree. It mattered not who took the gun in hand, the average difference was always about the same. The recoil of the gun was much less with gun-cotton than with powder. This is very well known, but we are disposed to venture a different reason for it from the one commonly given. It is usually said that the gas produced has to move solid grains of powder as well as shot. The difference must be very trifling, and cannot possibly account for the extraordinary want of kick in guns fired with gun-cotton cartridges. We believe that the action of the gun-cotton is more local because more rapid, and expands itself in creating motion in the particles near at hand when the explosion occurs, rather than in moving the whole mass of the gun. This theory seems to be confirmed by the fact that as gun-cotton is more diluted by inexplosive cotton it gives more recoil. If we are correct in this supposition, it is clear that the gun-cotton strains the gun more, but fowling-pieces have generally a large margin of strength, and the charge of shot moves much more readily than a bullet in a rifle. This supposition may also account for the closer throwing of shot from the gun, for the greatest pressure of the gas occurs while the shot is yet far from the muzzle; hence less tendency to separate at the momont of leaving the gun.

As the first experiment against palisades, a disc of gun-cotton, weighing about 1 lb. 1 oz., was placed on the stump of a tree lately cut down and ignited by an ordinary piece of miners' fuse. At the instant of ignition it was enveloped in flame and sailed merrily about for the two or three seconds required for its combustion. The gas produced lifted it up and caused it to move. Then about half the quantity was placed on the same spot and ignited by a small detonating tube. A sharpe, sudden report was heard, and the stump was found on inspection to be partly penetrated just where the charge had lain, while the twigs of the hedge close by suffered severely. On seeking for a new illustration, a large tree-root was seen which had been torn out of the ground, and offered among its gnarled and bossy structure a favorable position to deposit a charge. One of the discs about 1 lb. 1 oz. was accordingly placed at the mouth of a small cave that seemed inviting. The gun-cotton was not buried in the mass, but only laid as it were on a shelf perfectly open to the air. The gentlemen present retired to what they considered a safe distance, about 50 yards. There seemed to be some doubt about the effect. Is it possible that so small a quantity of gun-cotton could rend such a mass even if buried in it? Surely not when it is only laid on the floor of an opening. The moment of explosion is anxiously awaited. A man lights the fuse and runs for his life. There is a little smoke. Is the cotton burning as the first sample did? Wait a little yet. The tube has not given its sharp cracking sound. One moment more, and then a report and a rush through the air of masses of wood. Overhead, right, left, in front, everywhere. Soldiers who have known what it is to be under shell fire ducked to dodge a big lump of knotted wood that sprang 64 yards from its parent root, just clearing the heads of the party. It was only for a moment, and then everybody ran to see what had been done. The whole great root had simply been shattered to pieces. The next experiment was on a row of palisades composed of three trunks, some of them eighteen inches in diameter, and all sunk four feet into the ground. A long tree-trunk lay touching the foot of the palisade, and upon this 5 lbs. of gun-cotton was laid. Wires communicating with a magnetic apparatus were affixed to a detonating tube, which was placed in contact with one of the discs of gun-cotton. The time of suspense was short, and then the explosion was heard. One mass of wood only was seen to plunge away from the palisade; it was the recumbent trunk upon which the cotton had been laid. The palisades themselves were standing, though a good deal damaged. No practicable breach.

But there still remained a long space of palisading yet untouched, and here, instead of 5 lbs., 15 lbs. were laid, partly built upon each other. The excitement began to increase. It was the old story of the targets and the guns, and now several people might have been found to back the palisades. Fuse and wires were placed. Everybody retired to a safe distance. At last came the sharp, powerful crash, so unlike the dull roar of gunpowder, and this time there could be no mistake about the effect. Huge logs were seen performing somersaults at greater or less distances from the explosion, while smaller pieces, some about a couple of feet square, bounded like rabbits over the field. On reaching the target the effect appeared to have been tremendous. In some places a tree-trunk had been cut in half almost as if with a rough saw, only not so straight.

In others the solid wood was mangled so that it could be pulled to pieces by the hand. Three logs had been cut down or smashed, and it was clear that no stockade or New Zealand pah could withstand such deadly effects for an instant.

And all this had been done by only 15 lbs. of the cotton. Three times the quantity made up into a cylinder could be carried with ease by a man at a run, who might also drag the ends of the two wires as they unwound from a reel kept in a position of safety. No fire need be seen, for there is no match to light. Surely plenty of volunteers could be found to perform such work at night, and so restore the superiority of civilized man over savages! It had been contemplated to tie a ring of gun-cotton round a living tree, and see if it could not be cut down, but there was not time enough. The experiments were over for the day, and the visitors returned to London satisfied that they had seen a most marvellous phenomenon, and one which is only a first step to a whole array of novelties in the arts of war and of peace.

FRENCH NAVAL ENGINES.

Notes on the comparative experiments on three cylinder Engines in the Imperial Marine, by M. le Vice-Admiral Labrousse.

Translated for "Van Nostrand's Magazine" from "Le Génie Civil."

(EDITOR'S NOTICE).

The readers of "Annales du Génie Civil" will recall that one of the most important questions connected with the application of steam to war vessels, has been already discussed in our magazine. We refer to the determination of the relative merits of two systems, simultaneously employed in our navy. The one, derived from the Woolf system, (but which does not make use of very high pressures nor of great expansions,) introduces the steam directly into a central cylinder, during $\frac{85}{100}$ of the stroke, and then allows it to expand into two other cylinders attached to the first and of equal capacity. The other system, which employs steam at a moderate pressure, gives it access to each of the three cylinders through $\frac{30}{100}$ to $\frac{65}{100}$ of the stroke, according to circumstances.

Vice-Admiral Labrousse, as the result of prior experiments and the most exhaustive theoretical considerations, endeavored in the article alluded to, to show that this latter system has incontestable advantages over the former, both in a mechanical point of view, and in its military relation, and concluded by insisting upon the immediate abandonment of the objectionable system, and the transformation of its machinery—a matter of no great difficulty. The arguments of the honorable admiral, whose qualifications in all that relates to steam engineering nobody will venture to question, have not, it would seem, been regarded by the directing administration as sufficiently conclusive to warrant the instant adoption of so sweeping a decision; but it has seemed advisable to seek in new experiments a more decided and authoritative comparison and more accurate results upon so grave a question. During the past summer many instructive experiments were undertaken by the iron-clad division of the navy; the programme, it is but justice to say, having been arranged by M. Puys de Lôme, the author of these same engines which are charged with inferiority. In this case, as in all others, to the party on trial belongs the right of the last word in his defense, until the investigation is completed, and the judges are ready to render a decision. It certainly seems that the time for a decision has fully come, and any further postponement of the issue will look like favoritism, and can only, in the opinion of the admiral, aggravate a situation already most deplorable, nay even fatal, and upon which they cannot, in any other way, shed one ray of light. With a view to bringing home to learned and impartial men his own convictions in this matter, the honorable admiral submits to their judgment all the steps of his investigation, the results of which supremely affect the interests and honor of France, relating as they do to one of the capital elements of her military power. If we were to express merely our own opinion, we should say that our conviction, already prepared by the previous paper of M. Labrousse, is now complete; for it seems impossible to oppose a single valid argument to inferences so clear and convincing. But it is to the enlightened public, to whose judgment the admiral makes his solemn appeal, that the right belongs of deciding between the two opinions before it on this grave question—COMITÈ DE REDACTION.

The armored frigates *Savoie*, *Gauloise* and *Guyenne*, which form a part of the Oceanic naval division, were subjected, a while ago, to some comparative experiments, relative to power and consumption. The *Savoie* has an engine with three equal cylinders, with direct admission into one of them; the *Gauloise* has also three equal cylinders, but with direct admission into all of them; the *Guyenne* is furnished with the ordinary two cylinder engine. The experiments, conducted according to a carefully elaborated programme, have been made with the utmost care. "Nothing whatever," says the report of the commission presided over by Rear-Admiral d' Hornoy, "has occurred to interrupt their course, or to affect, in the smallest degree, their validity." We may therefore consider the results as having all the correctness which is consistent with the official programme. In a former paper, containing an examination of the three cylinder engines, we had arrived at some summary conclusions, founded upon various theoretical considerations, which arose from an exhaustive discussion of the experiments before us. We put them in the following form:

If we compare the new engines of the *Savoie* type with the three independent cylinders of the *Gauloise* type, we must conclude from the foregoing discussion that the latter are superior in every respect.

1. They are on the same footing with respect to consumption of fuel, and yet the latter have attained, with a boiler pressure less than 59 centimetres [of mercury], a power in excess of 4,000 horses.

2. They offer better security for attaining a great number of revolutions, because their method of coupling is more regular [equiangular], because the maximum pressure upon the journals is 50 per cent less, and because injurious effects of heat are less to be apprehended.

3. The static equilibrium of those parts subjected to alternating motion, is more exact—a result of the more regular manner in which the cranks are attached to the shaft.

4. To attain a normal power of 4,000 horses, we can in the engines of the *Gauloise* type, reduce the working velocity adopted for those of the *Friedland* or *Savoie*, either by increasing the pressure (without reaching even 133 centimetres), or by increasing the admission; while in the *Friedland* or *Savoie* type, this power cannot be attained except by exceeding the normal pressure of 133 centimetres, and increasing the working velocity, which is already too high.

5. Finally, as the normal admission in an engine of the Gauloise type, is only $\frac{4}{10}$, when the boilers are deteriorated, we can, without diminishing the power, employ a larger admission, and thus work at a lower pressure, which is impossible with the new engines, in which the admission is already $\frac{85}{100}$.

The experiments with the armored vessels of the Oceanic division, have confirmed these various assertions in the most complete manner, and all the more conclusively because they were conducted upon a programme laid down by the very author of the *Savoie* type of engine. We shall set out these facts in a manner that ought not to leave any doubt in the mind of any reader, however prejudiced in favor of the latter system.

Meantime we may venture the remark, that our object is only to establish an abstract and general comparison between ordinary engines and established machinery after the Woolf system, (properly speaking,) with high pressures, which involve the use of surface condensers when sea-water is the only available source of supply. This will give rise to a question which we shall probably have occasion to touch upon further on, when we come to discuss the military requirements of a vessel. Our present task is less complex. In a word, it amounts to this:

The French fleet contains, either in service or building, nine three-cylinder engines of a thousand nominal horse-power; two with independent cylinders, and seven with direct admission into only one cylinder, according to a system derived from the Woolf principle. In all these engines the boilers are fed with sea-water. The pressure in the boilers should therefore be limited, in the seven engines of the second type, to 133 centimetres—a maximum, beyond which the author of these engines himself admits that deposits of salt cannot be avoided. What we urge is the transformation of these seven engines into engines with direct and independent admission into the three cylinders, for the sake of advantages of every kind, mechanical and military, which undeniably appertain to the latter class. The conversion can be effected with little difficulty, and without affecting materially the internal arrangements of the vessels, and we have already seen by the analysis and discussion of the experiments made with the armored division of the north, that delay in this matter is no longer tolerable. But we proceed to our demonstration.

1. *Experiments proving à fortiori, our first conclusion; greater power with less boiler pressure and equal consumption of fuel.*

TABLE I.

NAME.	Pressure, Centimetres.	Power, H. P.
Savoie	115.8	2,565
Gauloise	60.	3,157
Difference	55.8	592

These figures show at once in favor of the Gauloise an actual power one-fourth greater with about half the pressure.

The consumption of coal, in the determination of which no possible means were neglected which might ensure perfect exactness, are compared in the following:

TABLE II.

Relative consumption per hour and per horse-power of 75 kilogrammetres.

NAME OF VESSEL.	1 BOILER. Consumption.	1 BOILER. Saturation.	2 BOILERS. Consumption.	2 BOILERS. Saturation.	4 BOILERS. Consumption.	4 BOILERS. Saturation.	6 BOILERS. Consumption.	6 BOILERS. Saturation.	8 BOILERS. Consumption.	8 BOILERS. Saturation.
	K.	°	K.	°	K.	°	K.	°	K.	°
Savoie...............	1.967	2.690	1.484	2.480	1.485	2.49	1.494	2.240	1.543	2.32
Gauloise..............	1.940	2.825	1.603	2.800	1.454	2.76	1.390	2.734	1.369	2.75
Difference	+0.027	......	—0.119	......	+0.031	....	+0.104	......	+0.174	.....

TABLE III.

Consumption reduced to 3° of saturation.

NAME OF VESSEL.	1 BOILER. Consumption.	1 BOILER. Saturation.	2 BOILERS. Consumption.	2 BOILERS. Saturation.	4 BOILERS. Consumption.	4 BOILERS. Saturation.	6 BOILERS. Consumption.	6 BOILERS. Saturation.	8 BOILERS. Consumption.	8 BOILERS. Saturation.
	K.		K.		K.		K.		K.	
Savoie...............	1.929	3°	1.428	3°	1.433	3°	1.400	3°	1.460	3°
Gauloise	*1.920	3°	*1.579	3°	*1.432	3°	1.365	3°	1.331	3°
Difference	+0.009	....	—0.151	....	+0.001	....	+0.035	....	+0.129	....

The report of the commission gives, for the consumption reduced to three degrees of saturation, the figures in place of

1,876	1,605	1,463
1,920	1,579	1,432

which are given respectively in table III, and which are marked by an asterisk. It is apparent that some sensible errors have crept into the reductions made by the commission, and we have worked out the corrections, after having made sure, in comparing the total consumptions, the duration of the experiment, and the horse-power obtained, as set forth in the tables of the commission, that the figures 1,940, 1,603 and 1,454 are correct.

It appears from the foregoing tables that the advantage rests with the Gauloise in every case but one, and that with two boilers—that is, with one-fourth the fires lighted—an exceptional case, which we have never seen in actual service.

With respect to the power developed, it was during the trials of June 27th, 1868, greater by about 600 horse-power (or one-fourth greater) on the *Gauloise* than on the *Savoie;* while the pressure, which was 115.8 centimetres on the *Savoie*, did not exceed 69 centimetres on the *Gauloise*. The first of our conclusions is thus confirmed, even beyond our expectations; but even though the commission had reversed the results—that is to say, even though the *Savoie* was made to show in the report of consumptions an advantage which properly belonged to the *Gauloise*, we none the less continued to urge the conversion of engines of the *Savoie* type into the *Gauloise* type, taking our stand upon the following considerations, which we explained in our first paper upon these engines.

"An economy reaching even 20 per cent (M. Dupuys de Lôme's figures in his note to the Academy) is not sufficient to compensate for the defects of his engine. The defects are all the more serious because their principles may pass unobserved in time of peace; for the occasions on which the machinery of our war vessels will be called upon to develop their utmost power, will be rare and of brief duration; but in war, and in the hours of supreme emergency, the speed, which, in M. Dupuy de Lôme's engines requires the highest pressures and a perilous velocity of the piston, will be often demanded and will be had whatever the cost. Their dangerous character will then be fully realized."

We proceed to examine our second conclusion. The more perfect equality of the couple of rotation in the *Gauloise* engine, appears from the fact reported by the commission, that the *regular* motion may be reduced down to nine revolutions [per minute], while in the *Savoie* it ceases to be regular at twelve turns [per minute]. If the power may be regarded, within the limits compared, as proportional to the cubes of the number of turns, then the minimum forces consistent with the regular performances of the two will be in the ratio of 729 to 1,728, or as 1 to 237. The first part of our second conclusion then is abundantly warranted by the experiments of the Ocean division.

With respect to the second part of that conclusion, viz: maximum pressures upon the journals; it is well sustained by results. We have elsewhere demonstrated that, supposing the mean pressures to be equalized in the cylinders of the *Savoie*, the interposition of inertia would involve a great increase of relative pressures upon the journals. This increment of pressure will be greatly augmented in the present case, because the mean tensions of the steam are widely different in the different cylinders. Finally, we asserted that injuries resulting from the high temperature of the steam are less to be feared in the *Gauloise*. We infer this from the fact that about the same powers are obtained on the *Gauloise* (3,157 horses), with 60 cm. of boiler pressure, representing 117° C., and on the *Savoie* (3,215 horses) with 141.8 cm. of pressure, representing 134° C.

Our third conclusion as to the static equilibrium of moving parts was evidently correct *à priori*, so far as it applies to the *Friedland* type of engine, of which the cranks are attached at 90 and 135 degrees. On the *Savoie*, where the cranks are attached at 120 degrees, (the same as the *Gauloise*), the inferiority of the static equilibrium shown in the experiments, results from the difference in the tension of the steam in the cylinders, which the attachment at 90 and 135 degrees is expressly intended to obviate, but is more injurious than useful in the present case.

Our fourth conclusion is with reference to the means of obtaining great power with low pressures in the *Gauloise* type. This would be evident enough *à priori*. But to show that it is sustained experimentally, it may suffice to quote the figures. The *Gauloise* has developed 3,544 horse-power with $\frac{4}{10}$ admission and 88.8 cm. of pressure, while the *Savoie* has developed only 3,215 with 141.8 cm. Comment is superfluous.

There remains the fifth conclusion, viz: sustained power in spite of deterioration in the boilers. The Gauloise realized (17th of June) 3,157 horses with only 60 cm. pressure, while the Savoie, to realize an equal power (3,215 horses), had to push the pressure to 141.8 cm., and with 105 cm. her power reaches only 2,207 horses; indeed at this moment the boilers of the *Magnanime*, (same engine) though in good condition as yet, are so weakened over the fires, that it is not deemed prudent to exceed 100 cm. of pressure, and the engine is barely capable of developing more than 2,200 horse-power; while if it had belonged to the Gauloise type it might, with this pressure, attain 4,000 horse-power, as has been experimentally shown in the Gauloise.

Altogether, the last experiments in the armored Ocean squadron have brought clearly and thoroughly to light all the defects we had charged upon the engines recently introduced into the Imperial marine, and justified the conclusions we had formed. A single one of these conclusions, (that one *à fortiori* in favor of our opinion,) has not been found exactly in accordance with the facts. It is that relating to economy of fuel. In view of precedents, we had asserted that the consumption of fuel for the whole amount of steam generated would be about the same in both types. In actual experiment the *Gauloise* showed a marked advantage over the *Savoie*. In view of results so complete and convincing, we need not wonder that the superior commission expressed itself as follows at the announcement of its conclusions: "The facts speak for themselves. The comparisons of the three types of engines have, in the opinion of the superior commission, demonstrated the advantages of the three cylinders with direct admission of the steam, &c."

Since "the facts speak for themselves," we shall add nothing to our argument, and conclude by saying that the conversion of all the Savoie and Friedland engines into the other type, with three independent cylinders, should be no longer deferred.

Vice-Admiral Labrousse.

A NARROW GAUGE RAILWAY.

THE BRÖELTHAL VALLEY LINE—TWO FT. SEVEN IN. GAUGE—PARTICULARS OF THE ROAD, ENGINES, CARS AND WORKING.

Compiled from "Engineering."

The railway connecting the valley of Bröl with that of Sieg, near Cologne, of which we propose to give some particulars, is of interest to engineers not only on account of the narrowness of its gauge, which is 2 ft. 7 in., but also on account of the success with which its working has been attended. The line leaves the Cologne and Giessen Railway, at Hannef, and with the exception of a short length near that station it is constructed along the line of the ordinary road, the administrative authorities having permitted a width of about 4 ft. 8 in. to be taken from the latter for the purposes of the railway.

The Bröelthal valley line was originally designed exclusively for the accommodation of the mineral traffic to the works of Friedrich-Wilhelm-hutte; but the inhabitants of the surrounding districts found it to be to their interest to employ the line for the conveyance of their goods, as the cost of transportation was found to be about 66 per cent cheaper than by the ordinary roads; and as a result the line has at the present time a considerable general goods traffic. The main portion is about $12\frac{1}{4}$ miles in length, and with the exception of about $\frac{5}{8}$ mile is constructed, as we have already stated, along the ordinary road. At a station called Schöneberg, a branch about $1\frac{1}{2}$ miles in length extends to Sauerbach. The company are also on the point of extending the main line from Ruppichteroth to Waldbröl, a distance of $6\frac{1}{4}$ miles; and as this portion of the line cannot be constructed along the ordinary road, the Prussian Government have granted the company a subvention of 60,000 francs (£2,400), in return for which the company have engaged to establish a passenger service over their whole system. The stations on the main line are eight in number. Besides these there are watering stations for the supply of the locomotives. All the buildings are of the simplest kind, and the arrangements for supplying water to the locomotives consist simply of wooden cisterns filled by hand pumps.

The railway follows exactly the course of the road, and it includes curves of 38 meters (124 ft. 8 in.) radius, and inclines of 1 in 80. The line is always carried on the most dangerous side of the road, and it occupies a width of 4 ft. 8 in., the total width of the road being 24 ft. 9 in. Permission has also been given, in case of a new line being laid down, to increase the width occupied to 6 ft. The upper sides of the rails are on a level with the footpath, and at intervals channels are provided for the escape of the drainage water. Near Hennef, the line, together with the road, passes over the river Sieg on a wooden bridge, which was constructed at the expense of the company, but of which they keep in repair only that portion traversed by their line, paying for the maintenance of the remainder an insignificant annual sum.

At Hennef the Cologne and Giessen line is above the level of the surrounding soil, and a siding serves to conduct the larger wagons to hoppers, into which the minerals are discharged, and from which they are delivered into the wagons of the Bröelthal valley line. At the basement of the range of hoppers are the goods offices, and a running shed and turn-table for the locomotives, and a weighing machine.

The line is worked by two small tank locomotives, these engines running alternate weeks. These locomotives were constructed at Carlsruhe. They have six driving wheels in a rigid frame, and outside cylinders. The principle dimensions are as follows:

	ft.	in.
Diameter of cylinders	0	$10\frac{13}{16}$
Stroke	0	10
Diameter of wheels	2	$3\frac{1}{4}$
Distance between centers of leading and driving wheels	3	$8\frac{1}{8}$
Distance between centers of driving and trailing wheels	2	11
Total wheel base	6	$7\frac{1}{8}$
Diameter of barrel of boiler	2	$9\frac{7}{8}$
Number of tubes	73	
Length	5	7
Diameter	0	1.38
Length of firegrate	2	4
Width	1	$6\frac{1}{2}$

Heating surface.

Tubes	147 sq. ft.
Fire-box	27 "
Total	174 "

Area of fire-grate	$4\frac{1}{4}$ sq. ft.
Pressure of steam	90 lb. per sq. in.
Weight of engine in working order	$12\frac{1}{2}$ tons.

The wagons employed on the line are almost all of the following dimensions, etc.:

		ft.	in.
Length of body		10	2
Width		4	8
(In the new stock this width will be increased to 5 ft. 4 in.)			
Mean depth of body about		5	3
Diameter of the wheels	2 ft. $6\frac{3}{4}$ in. to	3	1
Wheel base	4 ft. 6 in. to	5	2
Diameter of axles	3 in. to	0	$3\frac{1}{2}$
Weight empty	$2\frac{1}{2}$ tons.		
Load carried	5 "		
Total weight loaded	$7\frac{1}{2}$ "		
Weight per wheel	$1\frac{7}{8}$ "		
Cost per wagon	£56 to £92.		

The bottoms of the wagons incline from the center downwards towards each side, so as to discharge the minerals through side doors. The longitudinal frames of the wagons are of iron of channel section; and the springs are arranged, as usual, above the axle boxes, the latter being protected by flaps of leather or canvass, as on ballast wagons, to prevent the dust from the minerals, when the latter are discharged, getting to the bearings. The wagons have central buffers placed above the draw hooks, each buffer rod being connected with the corresponding draw bar by a lever, so that the draw spring serves also as a buffer spring. The draw springs are of india-rubber. Some of the wagons have cast iron disc wheels without tyres, whilst others have wheels of the ordinary kind with tyres of puddled steel. At first the wagons were run with one wheel of each pair loose on the axle; but the results were not found to be satisfactory, and the plan was therefore abandoned.

The line is laid with rails of the following dimensions: Depth of rails, $3\frac{1}{8}$ in.; width of the top table, $1\frac{5}{16}$ in.; width of base, $2\frac{5}{8}$ in.; thickness of the web, $\frac{7}{16}$ in.; weight, from 22 lb. to 26 lb. per yard. The rails vary in length from 14 ft. 9 in. to 21 ft. 8 in., and they are carried upon transverse sleepers of oak, 4 ft. 2 in. long, 6 in. wide, and $5\frac{1}{8}$ in. deep, placed at a distance apart of 2 ft. from center to center. In the case of the sleepers at the joints, the width is increased to 8 in. The rails are secured to the sleepers by spikes, and they are connected by fish-plates $12\frac{1}{4}$ in. long, held by four bolts $\frac{1}{2}$ in. in diameter. The gauge of the line is, as we have already stated, 2 ft. 7 in., but on curves of 40 meters (131 ft. 3 in.) radius the gauge is increased to 2 ft. $7\frac{1}{2}$ in. The super-elevation of the exterior rail on these curves is from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. A trial was made on the curves of small radius of ordinary flat-footed rails, weighing 72 lb. per yard, laid without cross sleepers, but the experiment was not successful. Formerly also movable rails were used instead of the regular points; but now ordinary switches are employed. The crossings are made of hard cast iron. The extension of the line from Ruppichteroth is to be laid with rails weighing 34 lb. per yard, but the distance between the sleepers is to be increased, and they are to be placed at a pitch of 2 ft. $11\frac{1}{2}$ in. from center to center. The rails laid on the main line, between Hennef and Ruppichteroth, cost £8 18s. per ton, and the fish plates £12 12s. per ton. About 15 tons of rails and 1,000 sleepers are used annually in keeping up the line.

We must now say something concerning the manner in which the line is worked, and its commercial results. The usual load drawn by the engines consists of 28 wagons loaded with five tons each, giving 140 tons of paying load. The total weight of the train is thus, as follows:

	Tons.
Locomotive	$12\frac{1}{2}$
Wagons	70
Load in wagons	140
	$222\frac{1}{2}$

It is found that the engines can easily draw 36 loaded wagons, but the above is the usual load. The speed on the level portions of the line is a little over nine miles per hour; and in traversing those portions of the road at which there are habitations, this speed is decreased to about $5\frac{1}{2}$ miles per hour. In case of meeting a vehicle with horses not accustomed to the passage of the train, it is the rule to stop, and by means of the brakes, which are in charge of five men, the train can be brought to a stand in a distance of about 130 ft.

But one train is run over the line each way per day. This train leaves Hennef at 6 A. M., and arrives at Ruppichteroth at 8. 30 A. M., departing from the latter place at 1 P. M., and arriving again at Hennef at 4 P. M. The line is worked with but a small staff. The managing director is M. Gustorff, who resides at Cologne, and who is also the managing director of Friedrich-Wilhelmhutte, while the line is in the special charge of M. Saling, who bears the title of inspector, and whose head-quarters are at Hennef, where a book-keeper is also employed. Another sub-inspector is stationed at Schöneberg, and three men are employed in keeping up the line, one of them receiving 1.875 francs (about 18d.), and the two others 1.8 francs (rather less than 15d.) per day. The men in charge of the train, and their wages, are as follows:

	s.	d.	
1 Engine driver	3	$1\frac{1}{2}$	per day.
1 Fireman	1	8	"
1 Guard	2	1	"
4 Brakesmen, each	1	7	"

There are no signalmen employed on the line.

The merchandise transported is divided into four classes, which are carried at different charges, the goods comprised in the first class being those least liable to injury. The tariffs are as follows:

Class.	Charge per ton for the entire distance. s.	d.
1st. Minerals, limestone, etc	7	0
2d. Burnt lime, iron, bricks, etc	8	0
3d. Grain and fruits	9	5
4th. Miscellaneous. (The tariff for this class varies according to the weight.)		

The goods belonging to the three first classes are, in addition to the above tariffs, subject to a fixed charge of 4d. per ton for loading and unloading. During the year 1864 (the latest year of which we have detailed particulars) the total quantity of goods carried over the line amounted to 32,709 tons, this quantity being divided as follows:

Class.	From Ruppichteroth towards Hennef.	From Hennef towards Ruppichteroth.	Total tonnage for each class.
	Tons.	Tons.	Tons.
1st.	27,970	2,860	30,835
2d.	344	840	1,184
3d.	140	335	475
4th	50	165	215
	28,509	4,200	32,709

The total receipts for the transport of the above quantities of goods was £2,800, showing an average charge of a little over 1s. 8d. per ton; while the working expenses during the year were £1,452, of which £120 was fairly chargeable to the succeeding year. The difference between receipts and expenditure, available for interest on original cost, etc., was thus, £2,800—£1,332=£1,468. The working expenses were divided as follows:

	£
Charges for management	150
Traffic charges	188
Cost of traction	428
Station charges	177
Maintenance of way	234
Maintenance of rolling stock	216
Miscellaneous	59
	£1,452

During the year 1867 the receipts amounted to £2,584, and the expenses to £1,301, leaving a balance of £1,283 available for dividend, etc. The total cost of the line and rolling stock, etc., has been as follows:

	£
1. Permanent way of main line	9,114
2. Bridge over the river Sieg with accessory works	3,593
3. Branch line to Sanerbach	1,575
4. Stations and depots	3,363
5. Locomotives and rolling stock	4,165
6. General stores	505
	£22,317

The total cost was thus about £1,526 per mile for the total length of the line. The sum given under the fifth head is divided as follows:

	£
2 Locomotives with spare wheels	1,753
29 Wagons without wheels and axles	1,405
101 Axles with wheels	887
Accessories	28
Tools, etc	92
	£4,165

The estimated cost of the extension of the line, a distance of $6\frac{1}{4}$ miles, to Waldbröl, is £9,490.

THE SOCIETY OF ENGINEERS AND ASSOCIATES.

Without discussing, at this time, the objects and duties of institutions of engineers, we merely wish to call attention to the fact that this New York Society is in some respects differently organized from many others, and that it has in some respects done the best work of any of our societies. The movement which created the present Society of Engineers and Associates, had its origin rather in a feeling of what ought to be done in this direction, than in a conviction that the time had come when such things could be done. Its present success, however, proves that it has one essential and, among us, almost new element of life in it, viz: that its meetings are attractive. Of course the purest science and the dryest formality are the correct theoretical features of engineering meetings, but the first society in the world—the Institution of Civil Engineers in London—does not dispense with those appeals to taste, both æsthetical and physical, that are found necessary to bring men together for almost all purposes except daily and routine business. In a new country, especially when the results growing out of association for scientific purposes are not direct and immediate, the right men are few and scattered, and if not full of engagements in the evening, as well as in the day, they are glad enough to devote the few unoccupied hours to recreation. Now, a stiff meeting, in an upper room, with a bad light and worse air, is not likely to attract the overworked engineer. He may attend from a sense of duty, but as a rule the engineers' meetings of a city, thus meagerly provided with a professional home, will consist of the gathering together of two or three in the comfortable study of a fourth. But while such gatherings lack the grand element of numbers, in which there is strength, they possess the equally essential element of attractiveness. Now, by combining the two, men will come in numbers, and getting the men at stated times is three-quarters of the battle. When they see their peers about them, they will not be long in organizing ways and means to get at the information there is in them. Proceeding upon this principle, the Society of Engineers and Associates have held their monthly meetings in a parlor at Delmonico's. While the proceedings are purposely informal, rather than rigidly parliamentary, they are not aimless nor desultory. The membership is made up of the principal engine, machinery and ship-builders of the city, and there is, therefore, no lack of subjects upon which information is wanted and can be given. Nor are professional subjects alone considered. A great object is to promote good feeling among the members, and harmonious action in the business and enterprises they represent. An attractive meeting place, and an agreeable supper after meeting, are wise features of the plan. Anglo-Saxons, especially in England, find it necessary to dine together in order to accomplish any enterprise in which several interests are associated. But the parliamentary features are not wanting. There are standing committees, having chairmen and secretaries, to look after the various interests represented, and to prepare business for the general action of the Society. Thus the meetings, to which it is specially desirable to attract the talent and learning that would otherwise stay at home, are relieved from the formality of preparatory business, and the discussion of special, local, and, to the professional public, uninteresting details. At a mere nominal fee of $10 per year. proper persons not residing in New York are admitted to the Society. The annual meetings (the last Thursdays in January) are of a more general and entirely social character. The last annual meeting, at Delmonico's, called out a greater number of professional men, especially in mechanical engineering, than we remember to have ever seen collected before in this country. It included prominent builders from neighboring cities, and prominent officers of the Army and Navy, and distinguished scholars from our scientific schools. Altogether it was more like a conversazione of the Institution of Civil Engineers, in London, than any gathering that has heretofore taken place on this side of the Atlantic. In this way, in addition to its more local and business labors, the Society of Engineers and Associates is doing great good, by attracting together the right men, promoting acquaintance and good feeling, and thus *actually showing* people more in a few hours, of the usefulness and possibility of a more perfect and comprehensive organization, than could be taught them by years of individual theorizing.

LOCOMOTIVES FOR HEAVY GRADES.

A NEW SYSTEM.

Translated and condensed from Polyt. Centralblatt.

We find in the history of the locomotive not only an astonishing development of constructions, based on the principles of Trevithik and Stephenson, but also a great number of systems which, like those of Murray and Blenkinsop, affect the locomotion of the engine by means of a rail with spur-gearing lying in the middle of the track (mid-rail), or in some other similar manner, thus to enable the locomotive to ascend heavier grades. Baldwin, of Philadelphia, built in 1848, two engines according to this plan, for the Madison and Indianopolis railroad, and afterwards some engines with horizontal driving-wheels for smooth mid-rails were constructed by Sellers, for the Panama railroad. Recently, Fell made the bold attempt to construct a temporary railroad with very heavy grades and sharp curves over the Mont Cenis, in using a similar system. However, as the success of Fell's arrangements has become more and more doubtful of late, the heavy grade problem is attracting once more the attention of engineers. With a view of solving this problem, K. Wetli has published a pamphlet containing an elaborate expose of a new system, a general idea of which we intend to give our readers in the following lines:

Wetli's system has a distant resemblance to one of the older schemes of railway and locomotive construction for heavy grades. According to this older scheme, a short, strong screw, attached to the engine below its frame, and situated parallel to the track, is turned by steam-power and works itself along a concave mid-rail with oblique indentations, thus pulling the engine forward. Wetli's locomotive is also provided with a kind of a screw or rather a double worm-wheel, which, however, is placed at a right-angles to the track, its axis being about eighteen inches above the level of the rails. It consists of two strong screws, one right, the other left-handed, both fixed to the same axle, touching each other in the middle of this axle, and extending almost over the whole width of the track. This worm-wheel receives its motion by a connection with the driving-wheels of the engine. Its object is to help the engine along on steep gradients. For this purpose straight guide-rails are laid between the ordinary track-rails in a transverse position, corresponding to the thread of the worm-wheel. They are laid in couples, the two rails of each couple touching each other at an angle in the middle of the track, and reaching on the other hand the vicinity of the interior faces of the track-rails. They are nearly five feet apart. As these couples of transverse rails are strengthened by cross-beams inside the angle, the whole track has about the appearance of two parallel lines between which a succession of letters A are inscribed one above the other.

The described mechanism is not, however, intended to give motion to the engine exclusively, nor to act under ordinary circumstances. When on moderate gradients, and in favorable weather, the friction of the ordinary driving-wheels is sufficient to overcome the existing weight of the train, the engine moves on in the usual way and the worm-wheel does not touch, or scarcely touches the guide-rails. But as soon as, under less favorable circumstances, this friction becomes insufficient, a sliding of the driving wheels takes place, by which the thread of the worm-wheel is brought in contact with the transverse guide-rails, and from this moment the driving-wheels and the worm-wheel begin to work conjointly. These are the general principles of this new system, according to the account given in Wetli's pamphlet. The inventor and author further relates in an ingenious and apparently successful manner, the principal objections that might be made to his system, and finally claims for the latter the following advantages:

1. The wagons of ordinary railways can pass unaltered on the track of the new system.
2. The locomotives of the new system can pass unaltered on ordinary tracks.
3. The working capacity of the locomotive is fully utilized, because its power of traction can be and is considerably increased at the expense of its velocity at any such time and to such an extent as the circumstances require.
4. The rate at which the current working expenses rise with the greater steepness of the road, is considerably less in the new system than in the one actually in use on the Mont Cenis railroad.
5. The running of the trains is not dependent on the weather or other exterior circumstances, and all irregularities in the service of the road that might otherwise result from this cause, are thus avoided.

S.

EFFECTS OF PHOSPHORUS IN IRON AND STEEL.

From a paper read before the Chemical Society "On the Connection between the Mechanical qualities of Malleable Iron and Steel, and the amount of Phosphorus they contain," by Dr. B. H. Paul, and the ensuing discussion.—"Chemical News."

It is generally considered that very small quantities of phosphorus in malleable iron and steel are most prejudicial to the quality of the metal. Quite recently, an eminent metallurgist has stated as a fact that much less than .3 per cent of phosphorus produces a decided and injurious effect on steel. The author has, however, been unable to discover any evidence sufficient to justify such a conclusion, and still less any reasonable explanation of it. He has recently had an opportunity of testing the truth of this conclusion, by determining the phosphorus in some samples of the iron and steel made by the new nitrate of soda process from British pig-iron known to contain phosphorus. Seven bars of iron and two bars of steel, made by the Heaton process, were examined; their tensile strength and extension had been determined by Mr. Kirkaldy. The iron bars had a tensile strength of from 46,547 to 52,824 lbs. per square inch of area, and an extension, when subjected to this strain, of from 21 to 28.6 per cent of their length. The two cast-steel bars had tensile strengths of 80,916 and 106,602 lbs., and extended 3.3 and 13.7 per cent of their lengths. In the iron bars, the author found .144 to .38 per cent of phosphorus (average .237 per cent), and in the two steel bars .24 and .241 per cent. The author, therefore, thinks himself justified in asserting that the commonly received opinion on this subject does not always represent the truth.

Professor Miller has had opportunities of examining some of these steels. It fact, he might say that Dr. Paul's experiments had been suggested by himself. He had found in some careful analyses of his own, very unusual quantities of phosphorus, even in samples of high class iron—iron which worked well cold, and also at a red and bright yellow heat. It could hardly be doubted that in many statements of the composition of iron the amount of phosphorus found had been too low. The old method of estimating the phosphoric acid, which involved the throwing it down as iron-salt, was unreliable. The phospho-molybdate process, employed by Eggertz, was undoubtedly the best; but even this required the greatest care to avoid getting too low a proportion of phosphoric acid. It was very difficult to ensure the entire precipitation of the phospho-molybdate. One thing was clear from these experiments, namely, that the presence of from two to three parts of phosphorus in 1,000 of iron was not so detrimental as was generally supposed.

The President inquired how the phosphorus existed in the iron, and the form in which it was eliminated during Heaton's process.

Professor Miller could not speak with certainty of the condition of phosphorus in the iron; it probably existed as phosphide. It was, however, most certainly eliminated in the form of phosphate.

Dr. Price remarked that there was nothing new in the statement that such quantities of phosphorus might exist in wrought iron, but that with regard to steel he had yet to learn that .24 per cent of phosphorus could be present without injuring the metal. With regard to methods, he believed that the one at present in use was absolutely correct, that, namely, in which the phosphorus was separated as phosphate of iron, and then determined with magnesia. The molybdate method was excessively tedious.

Mr. Forbes said that in Sweden they would not receive for making steel, iron that contained .1 per cent of phosphorus. Many works had had to stop for want of ores that were free from phosphorus. For one mine of such ore there were ten which yielded ore containing phosphorus, and they would most gladly use it if they could. He could not agree with Dr. Miller that the amount of phosphorus in iron was under-estimated. The molybdate process was thoroughly understood in Sweden, and had been in use since 1856. Errors in the estimation of phosphorus could not be due to ignorance of that method.

Professor Miller explained that he only meant to say that the molybdate process required care. No doubt the results obtained by Eggertz were perfectly correct. In answer to the President, Professor Miller then gave a short account of the Heaton process. A quantity of the niter was placed in a wrought-iron pot lined with fire-clay; on this was put a perforated plate of iron, and 12 cwt. of melted cast iron from a cupola furnace were then introduced, with sand and lime. During the reaction, fumes, first white, then brown, next gray, were evolved. A violent flame and a roaring noise attended upon it. When again tranquil, the metal was emptied on the floor of the furnace; the slag ran out and the pasty mass was pressed between rollers. He was unable to tell the proportion of phosphorus in the slag. The crude cast iron employed contained 1.43 per cent, and the cast steel obtained under .3 per cent. A part, at least, of the phosphorus lost was certainly to be found in the slag.

Dr. Paul quite agreed with Mr. Forbes that Swedish steel was free from phosphorus. As far as he could learn, there was no other evidence in proof of the injurious action of phosphorus on steel.

DOES IRON IN BRIDGES DETERIORATE?

THE HAMMERSMITH SUSPENSION BRIDGE.

From "The Engineer."

A very interesting question has been put to the public in general, and to engineers in particular, by the Secretary of the Royal Humane Society, through the medium of the "Times." This gentleman has, it appears, remarked on the occasion of more than one boat race, that the pretty suspension bridge at Hammersmith is taken possession of by an excited crowd standing as close possibly as men can stand; and he has further perceived that on the passage of the contending boats beneath, this crowd surges from one side of the bridge to the other, and causes it to oscillate violently, as in the manner of suspension bridges on comparatively slight provocation. He has heard that in process of time iron crystallizes and becomes brittle under strain. He is aware that Hammersmith Bridge has been built a long time, and strained and shaken not a little; he fears, therefore, that the quality of the iron has been deteriorated; and dreading the consequence of the giving way of any portion of the structure during the approaching Oxford and Cambridge boat race, he wrote a very sensible letter to our contemporary, therein suggesting that the matter should be looked into a little. On Thursday week Lord Bury asked the Government, in the House of Commons, whether they intended to take any action in the affair, and was informed that the Board of Trade would send a competent engineer to examine and report upon the structure. Meanwhile one or two more letters have appeared in the "Times" on the subject, and notably one from the pen of Mr. G. Gordon Page, C. E.

It is not disputed that up to the present moment the bridge has proved itself to be strong enough to sustain any strain which sight-seers could put upon it. It has been densely crowded over and over again, and no important failure has ever taken place, nor have any but the most trifling repairs ever been needed. The assumption that an accident may follow if the public take possession of the platform on the 17th instant, rests simply on the theory that the molecular structure of the iron has been deteriorated by vibration under strain, or that the sectional area of some important members—such as the chains or the suspending links—has been reduced by corrosion. We must wait for the report of the Board of Trade engineer to settle these things. But, meanwhile, we may point out that the inquiry possesses peculiar interest, not only as regards Hammersmith Bridge, but all iron structures exposed to vibration while loaded. It has long been a vexed question among engineers whether iron does or does not become crystalline and brittle in service; and it will be no small achievement for the Board of Trade to advance our certain knowledge of the subject by the contribution of even one well verified fact. The controversy may be regarded as involving three different theories. According to one, iron invariably becomes brittle and crystalline under even the most moderate strains, provided it is kept in vibration for a sufficiently long period. According to another theory iron never becomes crystalline and brittle under any strain; and, according to the best, the metal changes its character only when strained above its limit of elasticity—that is to say, when it has been stretched to such an extent by any applied force that it will not, on the taking off of that force, return to its original dimensions. The second theory is now almost universally rejected as untenable by competent engineers. It is excessively difficult to prove which of the remaining two is right and which is wrong, for the following reasons: In the first place it is impossible to tell the exact strength of a bar without testing it till it breaks. Therefore it is not easy to determine whether any bar has been weakened by age and molecular change or not. We may try a bar now and find that it will stand eight or nine tons per square inch without permanent set. We may put this bar in use, test it at the end of twenty years, and find it stand just what it did before; but it by no means follows that this circumstance proves that no deterioration has taken place. To assume that the facts supported this latter theory, is to assume that the original test was as nearly as possible all that the iron would bear, so that no margin was left for deterioration, which might or might not be true ; but it is as we have said, practically impossible to test, in the first instance, any bars used in a structure like the Hammersmith Bridge, right up to the last limit without going beyond it. In the second place it is difficult to prove that a bar has deteriorated by any examination of the structure. Those who believe in the deterioration under vibration theory, maintain that the iron loses its fibrous nature, becoming crystalline and brittle. The assumption of deterioration is based on the presence of a crystalline internal structure in the bar, which it is believed the bar did not originally possess. Now it so happens that we know less probably about the internal structure of iron than about that of any other substance used in the arts. We never see anything but its outside. Break or cut an iron bar as we will, still we are on the surface. Thus, as is perfectly well known, a bar 10 ft. long can be broken into ten pieces, showing alternately a fibrous and a crystalline fracture. Moreover, it does not follow that fibrous iron must be stronger or better than crystalline iron. It is quite true that rails, axles, chairs, etc., which have broken after long service, usually give a crystalline fracture, but it has never been proved that we are not confounding cause with effect when we say that the rail or the axle was broken because it had become crystalline. It may be just as correct to say that the rail had become crystalline because it was broken, for anything proved to the contrary. Of course we do not mean to assert that the structure of iron or steel does not change during use, or that these metals do not deteriorate in service, for this is contrary to fact. We only desire to point out that it has not been definitely proved that iron becomes crystalline when caused to vibrate under strain; or that, assuming crystallization does take place under such conditions, it follows that the iron has become weaker because it is crystallized. Whether it is brittle because it has changed to the crystalline from the fibrous condition, or whether it has changed from fibrous to crystalline because it has become brittle, no one can say with absolute certainty. The brittleness is demonstrable, the cause is not. It has been argued, indeed, and with some show of reason, that there is no such thing as congenitally fibrous iron, but that fibrous fracture merely results from the drawing out and rearrangement of certain previously interlocking crystals when the iron is broken under test, just as an apparently amorphous mass of felt may be resolved into its constituent fibers by careful carding. The theory is not ours, and we neither endorse it nor dispute it. We cite it simply to show that there is at least one way of reconciling difficulties connected with the appearance of the fracture of iron.

As regards the examination of Hammersmith Suspension Bridge, we wish it to be borne in mind that even should the test bars, which we suppose will be taken from the structure and broken, show a crystalline fracture, the circumstances will not prove molecular deterioration. Neither will the presence of a fibrous fracture prove that the structure is perfectly safe and trustworthy. The point to which the Board of Trade engineer should devote his attention, is the degree of elongation manifested by the bars before fracture. If this is not considerable, it may be taken for granted that the iron has deteriorated, whether the fracture is or is not crystalline, because the bridge was built almost before hot blast iron was known; and there can be little doubt that whether very strong or not, the materials of Hammersmith Bridge were well made and originally ductile in a very high degree. If the inquiry is properly conducted, its results will prove very valuable. The least carelessness will render them useless.

Mr. Page's letter, to which we have before referred, contains certain interesting statements worth reproduction. Quoting a report by Professor L. D. B. Gordon, dated August 7th, 1862, he writes: "Hammersmith Bridge was erected in 1827; Engineer, W. Tierney Clarke. Total length between land abutments, 710.7 ft.; useful width of road, carriage-way, 20 ft.; two footpaths, each 5 ft.; total width, 30 ft.; span of main opening, 422.5 ft.; ratio of versine to span, 1-14.31; the total section of chains at the towers, 180 square inches; weight of a superficial foot of roadway, 63 lb."

As a matter of fact the bridge was completed in 1824, not in 1827. Mr. Page goes on to say that "Drewry, an authority on suspension bridges, states that the bars of the chains were proved up to nine tons per square inch. The greatest possible load has been assumed by Mr. E. Clark at 80 lb. per superficial foot, but this has been considered as excessive by many engineers. An experiment was made, which came under my notice, by packing men on a weigh-bridge, with a result of 84 lb. per superficial foot; but it is not within the limits of probability that such a crowd could accumulaté on any bridge. I gather from various authorities that 70 lb. per foot superficial may be assumed as a standard for the load that the platform of a bridge could contain. Such a load on Hammersmith Bridge would produce a strain on the chains of 8.86 tons, or 1.4 tons below proof strain."

Inasmuch as the maximum strain now allowed by the Board of Trade is but five tons, it is evident that the structure is nearly 45 per cent weaker than these regulations allow; and we confess that we think the apprehensions—the expression of which has led to the official inquiry—are very well founded.

We cannot better conclude this article than by appending a few particulars regarding the construction of Hammersmith Bridge, in addition to those given above, by Professor Gordon. His dimensions are substantially correct. The deflection of the main chains in the centre is 29 ft. 3 in. The tension on the iron at the points of suspension is 1.857 times the entire suspended load. The piers are of stone, 22 ft. thick, 42 ft. wide at the top, 72 ft. at the waterline, and 48 feet high, measuring from the carriage road. There are eight main chains, arranged in four double lines, two small chains being put one under the other on the outside of each footpath, and two principal chains on each side of the carriage way. The small chains each consist of three rows of 1 in. flat bar links, 8 ft. 10 in. by 5 in. wide, coupled by $2\frac{3}{4}$ in. round bolts, and covering plates $15\frac{1}{4}$ in. long by 8 in. broad and 1 in. thick. The large chains consist each of six similar rows of plate links. The vertical rods are 1 in. square, and stand 5 ft, apart.

THE ELLERSHAUSEN PROCESS.—Some very careful experiments have recently been made at one of our large ironworks. In order to test several kinds of iron, and to determine the waste with accuracy, the iron was melted in a cupola and afterwards weighed. Several varieties of ore were used. Analyses of the material at different stages are being made. We shall publish the results.

AMERICAN LOCOMOTIVES AND ROLLING STOCK.

From a paper by Zerah Colburn, before the Institution of Civil Engineers, March 9th, 1869.

In construction and working, the American railways represent little more than a modified application of English practice. When the systems of the railway machinery of the two countries are compared, many of the differences which first strike the eye are found to be external, rather than fundamental; and so, too, many of the peculiarities of construction now retained in America are due to the initiative of English engineers.

Pursuing the history of the introduction of locomotives into the States, it was observed that the first two worked in America were made in England in 1828, one by Mr. George Stephenson, the other by Mr. J. U. Rastrick. In the same year the engineers of the then contemplated Baltimore and Ohio Railroad visited this country, when Mr. Robert Stephenson suggested to them what was now the distinguishing feature of all American railway rolling stock, viz, the bogie, to be applied to the engines intended to work round curves of six chains radius, at that time proposed to be adopted. The bogie, which had grown out of William Chapman's invention of 1812, was then, Mr. Stevenson stated, in regular use upon the quays of Newcastle. Having regard to the character of the lines first constructed in the States, it was essential that the locomotives should be light and cheap, and the first engines made there, between 1830 and 1832, weighed only from three and a half tons to four tons. Some of the English-built engines imported at about that time had their leading wheels removed, and a swiveling bogie substituted. The bogie was not, however, exclusively employed. Considerable numbers of engines made by Messrs. Stephenson & Co., Messrs. Bury, Curtis & Kennedy, Messrs. George Forrester & Co., and Messrs. Braithwaite & Co., were afterwards imported, and worked as originally constructed; and, as late as 1855, at least one hundred locomotives of English construction, or made almost exactly upon Messrs. Stephenson's plans, could have been counted at work in the States. For many years wood only was employed as fuel, and as it produced great quantities of sparks, as annoying to passengers as they were dangerous to goods, much ingenuity was directed to the problem of separating and withholding them from the escaping smoke and steam; and the voluminous "spark arresters" were very successful in this respect, while they gave an individuality to the engines. Again the rigor of the American winters compelled the adoption of some kind of shelter for the enginemen and firemen; and this was afforded by the bulky, and often extravagantly painted "cabs," which imparted a novel appearance, but without in any way affecting the principles, or economical conditions of working, of the engine.

As high speeds were seldom attempted upon the early American lines, the greatest steam tractive power was sought and obtained, both by working high pressure steam and by employing driving wheels of small diameter. Thus, although, in 1835, the English built engines, and those copied from them, were worked at 50 lb. pressure, and had 5 feet driving wheels, it was not long before American practice settled upon 90 lb. to 100 lb. pressure and 4 ft. or even 3 ft. 8 in. driving wheels. It was soon found, however, that the adhesion weight upon a single pair of wheels, necessary to work up this increased steam tractive force, was too great for the strength of the way, and coupling was then resorted to; and now, with the exception of a few light tank engines on branch lines, there was not probably an engine in the States having single or uncoupled driving wheels. Four tons might be said to have been the maximum per wheel for many years, while three tons was the more usual average.

Compensating levers were now employed on all American engines, whereby the weight was not only equalized between the coupled wheels, but the effect of a jolt upon one pair was divided and distributed, through the springs and levers, upon the other pair. For some years, too, bearings of the outer ends of the springs of the coupled wheels were made to rest upon india-rubber blocks.

The details were then given of several descriptions of engines long worked on the Baltimore and Ohio and Reading railroads, as well as of those employed to work the incline of 1 in $16\frac{1}{2}$ and $1\frac{1}{4}$ mile long, at the Madison terminus of the Madison and Indianapolis railway. Compared with English practice, in which six-wheeled coupled engines had from 5 tons to 6 tons on a wheel, and eight-wheeled coupled engines had 7 tons on a wheel, it was observed that the subdivision of weight in American engines was carried about half as far again, or, in other words, that they averaged only about two-thirds as much weight per wheel, and that they thus required, for a given total weight, half as many more wheels. Except with smaller wheels, this could not be done on any practicable length of wheel base; but none of the American goods and bank engines, of which the particulars had been given, had wheels larger than 3 ft. 11 in. in diameter. There were objections also, of much weight, to coupling a larger number of wheels from a single pair of cylinders. It was more or less difficult, if not impossible, to preserve an exact equality in the diameter of the wheels, an exact parallelism of the axles, and exact equality in length of the coupling rods. The extent to which coupling had been carried in American goods engines had been due, in a great measure, to the following expedients. The coupled wheels were as equally loaded as possible; their tyres, in a majority of cases, were of chilled cast iron, since replaced by steel; and the former were cast, and the latter turned, nearly or quite to a cylindrical form, or with but little or no cone. The driving wheels were the middle pair, or, in the case of an even number of pairs, one of the pairs nearest to the mid-length of the wheel base; compensating levers were employed, and adjusting wedges had for some years been applied to the axle-boxes. The coupling rods, in many cases, were made without brasses, round steel bushings being fitted to circular eyes formed at the exact required distance apart in the ends of the rods. With the exception of the leading and trailing wheels, the coupled wheels were generally fitted with plain cylindrical tyres having no flanges. Outside coupling cranks, necessary with outside frames, had rarely been employed, and were never so now. The coupling rods were counterweighted within the wheels themselves, no attempt being made, in inside cylinder engines, to set off their weight against that of the cranks and attached parts. In other words, the coupling pins of the driving wheels were coincident, on each side of the engine, with the position of the crank in inside cylinder engines, and, of course, necessarily so in outside cylinder engines. The experience of American locomotive engineers had been to the effect that with this arrangement, which was the opposite of English practice, the axle-boxes wore more uniformly, and that there was less "knocking" where a little play in the horn plates had once begun. And lastly, the length of the crank being one-half the radius of the small coupled wheels employed, any inequality in the length of the coupling rods was attended with less slipping and binding than where, with larger wheels, the crank was but about one-third the radius of the wheel.

The general form of passenger engine now in use in the States was then described. It had in most cases outside cylinders—indeed, inside cylinders had not been built for many years—and it had invariably four coupled driving wheels and a four-wheeled bogie. The leading dimensions of the representative type of passenger engines were: cylinder from 15 in. to 17 in. in diameter, with a length of stroke of from 22 in. to 24 in., and coupled driving wheels of from 5 ft to 5 ft. 8 in. in diameter. Such engines would exert a tractive force of $3\frac{1}{2}$ tons to 4 tons in starting, for which their adhesive weight, assisted sometimes by sand, was sufficient; and thus they could get quickly away from stations, even with trains of a gross weight of 200 tons or more. Economy of fuel had not been studied to the same extent in American as in English locomotives: the blast pipes of the former were smaller, the draught more forced, the back pressure greater, and less expansion was attempted in the cylinders, the link motion being generally arranged to cut off at one-third stroke as a minimum, and at nine-tenths, or more, as a maximum. It was thus that boilers of moderate size were made to supply steam for work equal to 300 indicated horse power, or the exertion of upwards of 2 tons of draught upon a passenger train at a mean speed of 25 miles an hour; but there was nothing remarkable in the consumption of from 50 lb. to 60 lb. of coal per mile in such work. It was stated that on the Pennsylvania Central railroad—a line 356 miles long, with gradients of 1 in 100 and 1 in 55—the consumption of coal for both goods and passenger trains amounted on an average to about 70 lb. per train mile, the goods mileage being three and a half times the passenger mileage. The coal was of excellent steaming quality, and cost about $3\frac{1}{2}$d. in currency, or $2\frac{1}{2}$d. in coin, per train mile. At this rate a difference in consumption of 24 lb. of coal per mile would only cause a variation of 1d. per mile in the cost of fuel; and it had been argued that such a waste was better than the alternative of employing an engine 4 tons or 5 tons heavier, to work with a less rapid rate of combustion, a slower piston speed, and more expensively.

The goods engines were moderate in weight, had large cylinders and small wheels, and drew heavy trains at a fair speed, with a consumption of coal often amounting to 100 lb., or more, per mile. On the Pennsylvania Central railroad the standard type of this class of engine had ten wheels, of which six, each 4 ft. 6 in. in diameter, were coupled. The whole weight of the engine was only $31\frac{1}{8}$ tons, and of this but $23\frac{1}{2}$ tons rested on the coupled wheels, available for adhesion. The cylinders were 18 in. in diameter, with a length of stroke of 22 in. With 60 lb. mean effective pressure per square inch upon the pistons, those engines would exert a tractive force, less their own internal resistances, of rather more than $3\frac{1}{2}$ tons, or about one-seventh their adhesion weight, although in starting a train, or in ascending a gradient, with 100 lb. pressure on the pistons, the steam tractive force would be 6 tons, equal to more than one-fourth of the adhesion weight, the efficiency of which would then be assisted, when necessary, by sand. Details of the performance of some of these engines were next given. In one case, after allowing for gravity $8\frac{5}{8}$ lb. per ton, for a train, engine and tender included, of 1,040 tons weight, the total resistance would be 4 tons, and thus the work done on each mile was calculated to be equal to 24 horse power exerted for one hour; and if the estimates could be trusted, the consumption of coal per horse power per hour would not exceed $4\frac{1}{4}$ lb. to $5\frac{1}{4}$ lb. The speed probably was not more than 15 miles an hour, corresponding to 360 horse power. The policy of American railway managers, with respect to goods traffic, as it was also the policy of the managers of most of the French lines, was maximum loads at slow speeds, involving a minimum resistance per ton, and correspondingly a minimum working expenditure per ton.

No experiments upon the dynamical efficiency of American engines had been made, so far as the author was aware; but he had run an experimental train on the Erie railway, over the whole length of the line and back, a total distance of nearly 900 miles. The same engine was employed throughout the run, occupying in all nearly three weeks, making an average for each week day of about fifty miles. The results of these experiments appeared to show, that the resistance of bogie rolling stock, even under disadvantages, was less than that of English rolling stock, as ascertained by the best authorities, and also that the rate of adhesion to weight averaged considerably more in the States than in England. With respect to adhesion, as the surfaces in contact were identical with those on English railways—indeed the rails and tyres in general use in the States were commonly of English manufacture—any difference in this respect must be attributed partly to the influences of climate and partly to a better application of sand, when necessary to increase the bite upon the rails. The sand was dropped equally upon both rails, not in intermittent handfuls down a pipe on one side of the engine only, but by means of the hand gear and regulating valve since adopted on the North London Railway. The experiments in question were, no doubt, influenced by the favorable circumstances of weather, and something was to be allowed also for the great length of train drawn, very long trains having a less tractive resistance per ton on a level than short ones, and something, possibly more than was commonly supposed, might have been due to the use of oil-tight axle-boxes, the saponaceous compound known as "railway grease" being nowhere in use on railways in the States. Messrs. Guebhard and Dieudonné's experiments, made in 1867, on the Eastern Railway of France, showed a considerable diminution in the resistance of oil-boxed rolling stock, as compared with that fitted with grease boxes.

Of the mechanical details of American locomotives, considered apart from the details already touched upon, much might be said. There were differences, and they were numerous, but they involved no important principles. The chilled cast-iron wheel, however, for engine and tender bogies, and especially for carriages and wagons, deserve mention. No wrought iron wheels, so far as the author could learn, were now employed in the States, unless in a few cases for engine driving wheels; and wrought iron wheels, at first exclusively adopted, had been wholly abandoned on the Grand Trunk and the Great Western railways of Canada. The cast iron wheels were not only much cheaper, but they were more durable, and, if not safer, were at least equally safe. The wheels employed for passenger carriages were 2 ft. 9 in. in diameter, and weighed 5 cwt. The bogie wheels of engines, tenders, and goods wagons were generally 2 ft. 6 in. in diameter, and varied in weight from 4 cwt. to $4\frac{1}{2}$ cwt. They were cast of special mixtures of the best qualities of iron, the requisite conditions being great absolute strength to resist both sudden and progressive strains, and the property of taking a deep and uniform chill. But little of the cast iron employed for wheels had a tensile strength of less than fifteen tons per square inch, and it broke with a fracture, almost suggestive of fiber, and of a dark gray color, but when chilled of a silvery whiteness. The chilled wheels ran from two to six and even seven years, according to the traffic, before becoming so much worn as to require removal, representing a service of from 80,000 miles to 200,000 miles. Engine driving wheels of from 4 ft. to 5 ft. in diameter, had been cast with chilled faces, thus requiring no tyres, and chilled tyres, from 4 ft. to 6 ft. diameter and $3\frac{1}{2}$ in. thick, had been extensively and successfully employed at fair rates of speed, say 28 miles an hour.

Wood was almost exclusively employed as fuel, except upon two or three important lines in the coal districts, until within the last ten or twelve years. Iron fire boxes and copper tubes were then generally adopted; but for burning coal, steel fire boxes and iron tubes were now used. Of upwards of four hundred steel fire boxes in the engines of the Pennsylvania Central railway, some had been in use for six years or more. The tubes were set without ferules, and very little trouble, as the author was informed, was experienced either from leaking or cracking. It was worthy of observation, that the evil of "furrowing," by no means uncommon in this country, was unknown in the States, and no other explanation appeared available, than that the thinner iron employed there permitted of a certain elasticity in the structure of the boiler, sufficient to prevent the localization or accumulation of bending or other strains at particular points, or rather upon particular *lines* of resistance.

What were now understood as steep, or exceptionally steep, gradients were rare in the States. Some instances of such were cited, and it was mentioned that, in July, 1836, one of Norris' engines, weighing 6 tons $8\frac{1}{2}$ cwt., and drawing behind it, including tender, a load of 8 tons $11\frac{1}{2}$ cwt., ascended an incline near Philadelphia of 1 in 14, and 933 yards long, at an average speed of $15\frac{3}{4}$ miles an hour. The nominal weight on the driving wheels was $3\frac{1}{2}$ tons, but it was believed that a portion of the weight of the tender was made to bear upon the foot plate, thus increasing the adhesion.

With regard to the expense of maintenance, it was stated that the average cost of engine repairs in the States, exclusive of those renewals which amounted to building a new engine, might be taken as a maximum at 10 cents currency per train mile, equal to $3\frac{3}{4}$d. in coin. Of this, the absolute difference in the cost of labor and materials would account for nearly or quite 1d., leaving $2\frac{3}{4}$d. to 3d. as the cost at English prices. Again, the manner in which these repairs were conducted showed a want of system and organization, and the shops were not fitted with some of the appliances considered essential in this country. Whatever economy in repairs might attach to the American engines was due, after allowing for the moderate working speed, to three causes only, viz: the use of the bogie, of chilled cast iron bogie wheels (which could be renewed at a cost of from £2 to £2 10s. each, after allowing for the value of the wheel taken out as old iron), and of steel or iron fire boxes and iron tubes. About twelve or fifteen years ago, the average mileage of American engines, taking the full stock of the leading lines, was not above 15,000 miles yearly—now it was probably not far short of 20,000 miles, and on some lines it might be even more.

There remained the consideration of the carriage and wagon stock, with reference to its mechanical peculiarities and its commercial relation to traffic. The earlier American carriages were made upon the English model, but it was found not only that a short wheel base was required for six chain and nine chain curves, but also that side buffers aggravated the difficulty. The bogie, already in use on the engines, was, therefore, adopted for the carriages, and it was soon discovered that the length of body could be considerably increased, and that the longer it was the steadier it became. But the long bodies precluded the use of side buffers, and so the central buffer with a loose coupling took their place. End doors afforded an obvious means of economy in the structure of the carriage, and left the whole depth of the body below the window sills available for any combination of trussing, most effective for carrying out a comparatively long span. The end doors, with a continuous passage throughout the carriage, afforded obvious facilities for communication. The central passage required an additional width of carriage, and from 9 ft. to 9 ft. 6 in. was a common outside width; while in some cases, even on the narrow gauge, a width of more than 10 feet had been adopted. These widths allowed seats for four passengers across, and for the longitudinal passage dividing the seats. The seats had reversible backs, so that the passenger might face either way, the carriages running in either direction without turning. It was undeniable that the seating was not so roomy and comfortable as in an English first-class carriage, and that, as compared with a second-class carriage, there was a certain loss of space. It was equally undeniable that such carriages could never answer for short traffic lines, where forty, fifty, or more passengers had to leave, and as many more to enter, in a minute or a minute and a half. The long body, however, with end doors and platforms, possessed obvious mechanical advantages. Its length gave steadiness, and the depth below the window sills afforded ample opportunity for providing vertical stiffness without undue increase of weight. There were no cross partitions; there were but two doors where English carriages would require, for the same number of seats, according to class, from twelve to twenty-six; there was much less sash and glazing, while there was at the same time more light; there was an important saving in respect of draw-springs, buffers, buffer-rods and screw couplings, and there was every facility for applying brakes, as was always done in the States, to every wheel in the train, either from the platforms of the carriages themselves or from the engine. It was an advantage of the long body, with its corresponding weight and number of wheels, that the application of the brakes, however suddenly, did not produce the jolting of which passengers complained so much when the same thing was attempted upon English carriages. Passenger carriages upon the double bogie plan were made of various lengths, from 45 ft. to 60 ft. exclusive of the additional 2 ft. 6 in. at each end for platform and covering porch. They accommodated from sixty to eighty-four passengers, and weighed, empty, 12 tons and upwards, or from 16 tons to 22 tons loaded. Some notice was next given of Pullman's hotel car, and of the carriage built by the Messrs. Winans for the Emperor of Russia. The improvements which had been effected in the engine and other bogies were then alluded to, and a description was given of the oil-tight axle-box, as well as of Loughridge's and of Creamer's continuous brakes.

In comparing the cost of maintenance of American carriage and wagon stock with that on English lines, many considerations were to be regarded. To say that the cost, in

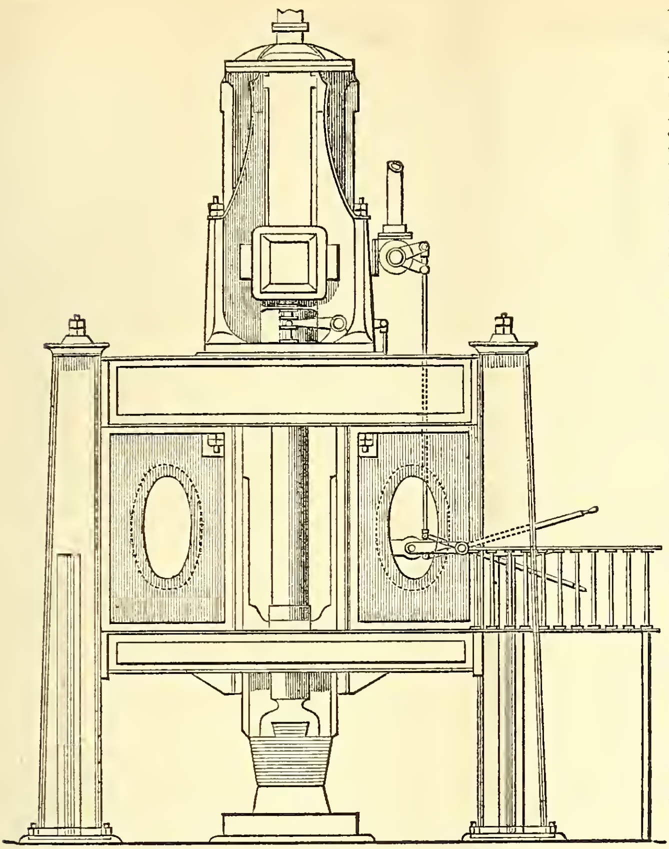
1867, on the 1,612 miles of railway in the State of Massachusetts, for a train mileage of nearly ten million miles, was 6.55 cents currency, or about 2½d. coin, per train mile, did not permit of any accurate deductions. In the States, the average number of passengers continuously carried over the whole distance made by a train was generally one-half greater than in England, although the proportion of dead weight to live load was probably nearly as high as in this country; the speed was less, and there remained the fact that labor and nearly all materials were much dearer. On the other hand, there was a considerable saving in the use of chilled cast iron wheels, such a thing as a wheel-turning lathe, for carriage or wagon stock, being unknown in the States; the maintenance of buffer and draw springs cost much less; the maintenance of the carriage bodies was cheaper, from their greater strength and simplicity of structure, and from the fact that there were no side doors to slam.

One objection to the use of chilled cast iron wheels, not referred to in the earlier portion of the paper, was that, being almost necessarily of the disk form, their weight increased in a ratio nearly as the square of the diameter, and thus the largest railway carriage wheels yet employed in the States were but 3 ft., and this size was long ago discontinued in preference for 2 ft. 9 in. In the case of cast iron spoked wheels, the chill was less hard opposite the ends of the spokes than elsewhere, and thus they soon showed flat spots.

It might be said, in conclusion, that if American railway practice were in any or many respects more daring than that which prevailed in this country, failure, if not too often repeated, was regarded in the cousin country as a misfortune, where here, unless it proceeded from causes absolutely beyond prevision, it was rightly regarded as a fault, a misdemeanor, or even a crime.

THE RAILWAY FERRY ON THE LAKE OF ZURICH.—The "Neue Zürcher Zeitung" gives some farther particulars of the work, which was generally described in "Van Nostrand's Magazine," No. III, page 208.—When the idea of a steam ferry was adopted, Mr. John Scott Russell, civil engineer and naval architect, was charged with making the necessary designs for it. Mr. Russell built, twenty years ago, the first steamer put upon the Lake of Zurich for the steamboat company at Schaff'hausen, and this steamer is considered up to the present day as one of the best crossing that water. The contract for the execution of the ferry boat was entrusted to Messrs. Escher, Wyss & Co., of Zurich, after a competition with several of the first class firms of England, France, Germany and Switzerland. The work was begun in January, 1868, at the works of the abovenamed firm at Stampfenbach, and the ferry boat was launched in the following October. For its propulsion a steam engine of 200-horse power (nom.) is employed. The fixed works required at the two ports, including two steel bridges (also designed by Mr. J. Scott Russell), in order to establish a direct communication between the shore stations and the ferry boat, had already been executed in Friedrichshafen under the direction of Mr. Brockmann, engineer of the Wurtemburg Railway, and in Romanshorn, under the direction of Mr. Seitz, engineer of the North Eastern Railway of Switzerland. These steel bridges are fixed at one end, which is on the same level as the rails in the stations, whilst the other end can freely move up and down in order to correspond with the level of the rails upon the boat, as conditioned by the different heights of the water of the lake, which varies at different seasons. These bridges and the ferry boats are provided with two lines of rails in order to carry at the same time two trains across the lake. The ferry boat itself is constructed strong and stable enough to resist even the most violent storm; its bottom is flat, and its upper works are partly covered in by a roof, which forms also a deck, from which the captain directs the course, and which may be also used by the passengers of the railway trains as a pleasant lounge during the passage. The time of crossing the lake is about one hour, and there exists no reason why other lakes in Switzerland, many of which are 50 to 60 kilometers long, should not be crossed in the same manner. The working expenses of such a system are not higher than those of a first-class railway, and the velocity may be increased from 20 to 25 kilometers per hour. The lakes would thus no longer constitute a severance between two districts or countries, but would become highways for increasing the traffic and for facilitating the communication.

We are glad to find, says the authority quoted, that Mr. John Scott Russell's abilities, which his countrymen, at least those of the world of science, cannot forget, thus appear to continue to find useful and congenial application.



Fifteen-Ton Steam Hammer for the Russian Government.—The engraving represents a so-called "50-ton" double-action steam hammer, which has been constructed by the Kirkstall Forge Company, Leeds, to the order of the Russian Government. The hammer frame, as will be seen, is, with the exception of the cylinder, constructed entirely of wrought iron plates. The valve gear is so arranged that the hammer can be driven at either side. Steam is admitted to the cylinder by an equilibrium slide valve, a conical valve being fitted into the upper passage, admitting either the exhaust steam from the under side of the piston, or the full pressure from the boiler to the top side when required, so that the hammer may either fall by its own gravity with the pressure of exhaust from the underside of piston added, or the blow is increased by the admission of full steam from the boilers. The piston and rod are forged in one piece, which, together with the hammer, weigh 15 tons. The cylinder is $46\frac{1}{2}$ in. diameter and 8 ft. stroke.—*Mechanic's Mag.*

Large Hydraulic Testing Machine.—Messrs. William Sellers & Co. constructed, some seven years since, a testing machine for the Pennsylvania Railroad Co., after the designs of J. H. Linville, Esq., President of the Keystone Bridge Co. The following are the principal dimensions: Piston, about $18\frac{3}{16}$ diameter; 260 sq. in. area; stroke, 2 ft.; thickness of ram about 9 in. The machine is mounted on a foundation of masonry 75 ft. in length. In front of the ram, and 29 ft. from the cross head, which is mounted on wheels and propelled by the piston, is another fixed cross head, coupled to the ram by 12 bars of iron 7 in. $\times$ 1 in. At this end of the machine, by use of differential blocking pieces, any sized specimen, up to 3 ft. diameter and 28 ft. in length, can be subjected to a pressure of 675 gross tons.

To the cross head in front of the piston is coupled a similar cross head, mounted on wheels in rear of the ram. Compression beams, 4 ft. in length, are secured to the masonry, with a movable cross head secured in notches in the compression beams. This end of the apparatus is used for testing large bars, to determine their tensile strength, and is now coupled to the forward cross head by bars proportioned to withstand a tensile stress of 130 gross tons. The pumps are double acting, with large and small piston for light and high pressure. The machine is supplied with two of Shaw & Justice's mercury gauges, and two spring gauges, also a weighing lever. For the last two years this machine has been in use at the Keystone Bridge Works and Union Iron Mills, Pittsburg, where the iron for all the Keystone Company's bridges is tested. The machine described in this Magazine (No. 4, page 346) is not, therefore, the largest in the country, and is similar to, but smaller than the machine, above described, which has been in constant use for seven years.

HISTORY OF DECARBURIZING IRON.

No. III.

The titles only of letters patent of the United States, prior to 1848, are published. No other information regarding these patents is accessible, except at the cost of manuscript copies from the Patent Office. After 1847, the claims of United States patents are also published. From 1855, engravings (such as they are), illustrating specifications, are published, and later still, abstracts of patents appear in the Patent Office reports.

There were only thirteen United States patents referring to the decarburization of pig iron, issued by the United States prior to 1847. Of these, four were prior to the date reached in our former article (1836), and are mentioned below.

Such matter as is accessible, regarding the United States patents after these dates, will be compiled in chronological order, for the present series of articles.

STEEL FROM PIG IRON.

LEONARD, ENOCH, Canton, Mass.—1812. January 16.

MALLEABLE IRON FROM PIG.

LEWIS, THOS. C., Pittsburg, Pa.—1830. October 1.

PUDDLING AND HEATING IRON.

JONES, WM., Haverstraw, N. Y.—1833. December 16.

PRESSING OUT PUDDLE-BALLS INSTEAD OF HAMMERING THEM.

JONES, WM., Haverstraw, N. Y.—1834. April 18.

PURIFYING CRUDE IRON IN THE FINERY AND IN THE PUDDLING FURNACE, BY MEANS OF DEFINITE PROPORTIONS OF CHLORIDE OF MANGANESE, BICHLORIDE OF CALCIUM AND CHARCOAL.

DUCLOS, EDWARD FRANCIS JOSEPH.—1837. October 20. No. 7,448.

Manufacturing iron. The invention consists in combining with "cast iron and its scoria, while they are in a state of fusion," metallic chlorides (as of manganese and calcium), whose bases combine with the iron and slag, while the chlorine combines with the volatile impurities, such as sulphur, given off by the iron. Both of these combinations are said to produce a beneficial effect upon the iron, and produce an alloy equal to malleable charcoal iron. The specification and drawings describe a refinery furnace having a crucible. About 30 cwt. of cast iron are introduced into the furnace when it is at a white heat, and immediately afterwards 336 lbs. of dry chloride of manganese, and 6¾ lbs. of bichloride of calcium or "bleaching powder," are put into the crucible. Over the mixture is put a layer of wood charcoal two or three inches thick, and over that a layer of scoria, of like thickness, mixed with sufficient quicklime to combine with the free silica contained in the scoria. The whole is then melted, and the surface of the metal is again covered with wood charcoal. "The usual tools for working the metal are then introduced," and during the working portions weighing ten pounds each of the chloride of manganese and bichloride of calcium, are thrown in at intervals. The surface is to be kept covered with charcoal, and in half an hour the refined metal may be run out. It is then puddled, and during that process the chlorides must be added at intervals, in proportions of about one per cent of the weight of the metal. The bridge of the puddling furnace is made double, and the space between is filled up with charcoal. When the slag has been run out, and the metal brought to nature, in order to free it from all silicious impurities, it is submitted to the action of a charcoal fire.

[Printed, 5d. See "London Journal" (Newton's), vol. 12 (conjoined series), p. 345.]

ORE AND LIME SUBSTITUTED FOR HAMMER SLAG IN PUDDLING—REFRACTORY STONE USED FOR PUDDLING FURNACE BOTTOMS.

GOSSAGE, WILLIAM.—1838. June 18 No. 7,693.

Manufacturing iron. A cheap material is used as a substitute for "hammer slag" in puddling pig or crude iron. Argillaceous ironstones calcined and powdered small are introduced into the puddling furnace with the pig iron, either alone or mixed with powdered lime, quicklime, or carbonate of lime. The proportions required vary according to the qualities of the ores; about 450 lb. of pig iron, 30 lb. of calcined iron ore, and five pounds of slaked lime, are beneficial proportions. If the cinder does not separate easily, more lime should be used, and if the metal does not sufficiently "boil up," more powdered ironstone should be added. Also, instead of cast iron for the bottoms or soles of puddling furnaces, grit stones or other fire-resisting stones slightly hollowed to receive the charge, are preferred and claimed.

[Printed, 4d. See "London Journal" (Newton's). vol. 15 (conjoined series), p. 445; vol. 17, p. 329; also Patent No. 6,908.]

FURNACE—REFINING IRON.

SHARP, JAMES, Liverpool, Pa.—1838. June 23. (U. S.)

NOTE.—*No specification published.*

USE OF TAP CINDER IN PUDDLING.

BRADLEY, RICHARD; BARROWS, WILLIAM; HALL, JOSEPH.—1838. August 21. No. 7,778.

Making iron. The invention consists in the use of "tap cinder" obtained from puddling crude iron, instead of the cinder obtained from puddling refined iron, as a protection for the bottoms and sides of puddling furnaces. Tap cinder is a cheaper substitute. It is prepared by breaking it in pieces about six inches in diameter, and roasting it gradually for about eight days in a kiln like a brick-kiln, which is fully described in the specification and drawings.

[Printed, 9d. See "Repertory of Arts," vol. 11 (new series), p. 149; and "London Journal" (Newton's), vol. 21 (conjoined series), p. 343.]

PRODUCING PURE CARBURET OF IRON — DECARBURIZING BY MALLEABLE IRON OR METALLIC OXIDES, SUCH AS CHROME OR IRON ORE—USING OXIDE OF MANGANESE IN PUDDLING—USING CARBURET OF MANGANESE IN MAKING CAST STEEL.

HEATH, JOSIAH MARSHALL.—1839. April 5. No. 8,021.

"Improvements in the manufacture of iron and steel." The specification describes and claims the invention under four heads.

1st. The extraction from "pure native oxides and carbonates of iron" of pure cast iron, without the intervention of flux or the production of cinder.

2d. Formation of cast steel by fusing the said pure cast iron with malleable iron or metallic oxides, in such proportions as to decarburate the iron to a certain degree, and by completing the decarburation in a suitable cementing furnace.

3d. The use of a certain portion of oxide of manganese in the process of converting cast iron into malleable iron by puddling.

4th. The employment of carburet of manganese in preparing an improved cast steel.

Under the first head the operation of producing pure cast iron is described. A blast furnace is filled with coke, charcoal or other equivalent fuel, and thoroughly ignited. The furnace is then first charged with twenty pounds of the pure ore to 100 pounds of fuel. Other charges are added at intervals, and the proportions of the ore are gradually increased at every charge, until they amount to 65 or 70 pounds of ore to 100 pounds of fuel. The ore is to be broken small to the size of peas, and will produce about 50 pounds of pure pig iron for every 100 pounds of fuel. The metal should be run into iron moulds. The metal produced is pure carburet of iron. This is converted into steel of any requisite hardness, by melting it in a cupola, with coke free from sulphur, or wood charcoal, using no more fuel than will just melt the iron, and burn away the carbon it contains to a considerable degree. The carbon is further "neutralized or removed" by adding scraps of metallic iron, or oxides of iron or of manganese. "taking care not to decarburate the metal to such a degree as to render it infusible, but to leave about as much carbon as exists in cast steel." To produce a superior cast steel "sesquioxide of manganese or peroxide, which had been previously ignited," should be employed. Sometimes oxides of chrome or iron are used. The steely metal so produced is run out into cast iron molds, and the ingots are "converted into steel of any requisite degree of mildness, by a further process of decarburation," by cementing it with peroxides of iron, or of manganese without charcoal in a cementing furnace, the period to which the metal is subjected to the heat being proportional to the degree of mildness required. The quality of malleable iron is improved by introducing from one to five per cent of pure oxide of manganese into the puddling furnace with the iron without mixing any other substance with it.

4thly. An improved quality of cast steel is formed "by introducing into the crucible bars of common blistered steel broken, as usual, into fragments, or mixtures of cast and malleable iron, or malleable iron and carbonaecous matter, along with from one to three per cent of their weight of carburet of manganese," and melting the charge, and pouring it into molds in the usual manner.

[Printed, 4d. The duration of the patent was prolonged, by an application to the Privy Council, for seven years. See for an account of the application for prolongation, and for reports of the ten various legal proceedings, Webster's P. C., vol. 2, p. 213 et seq. See also "Repertory of Arts," vol. 16 (new series), p. 104; "London Journal" (Newton's), vol. 15 (conjoined series), p. 221; also vols. 24, 26; "Mechanics' Magazine," vol. 39, p. 368; vols 42, 58; and other publications relating to patents and legal reports. See Patents Nos. 2,363, 3.697, 4,397, 6,837, 7,448, 7,762.]

NOTE.—*This is one of the most notable patents on record. The great value of using manganese in crucible steel making, which enabled British steel-makers to compete with foreigners and to use British irons to a certain extent, was here first pointed out by Mushet. But the British steelmakers managed, after many hard legal fights, to use manganese in a manner not strictly infringing Mushet's patent, and thus to rob him of all share in the profits that really grew out of his invention. This department of the patent will be considered in another series of articles. The compiler of the abstracts of the British specifications says: "This patent has been the subject of ten legal judgments, and been contested in every superior court in Great Britain. The most important feature of the invention lay in the discovery, by Mr. Heath, of a method of employing oxide of manganese in the manufacture of iron and steel beneficially, and with the certainty of controlling its powerful pernicious properties by the counteracting influence of carbon exposed to it in the requisite proportions."*

The features of the invention relating to the decarburization of iron, are the use of malleable iron scrap and the ores of iron, chromium and manganese. Employing malleable scrap for this purpose was specified by John Wood, in 1761 *(see Van Nostrand's Magazine, No.* 3, *p.* 194). *The use of ore in puddling was more fully specified by Mushet, in* 1835 *(see Van Nostrand's Magazine, No.* 4, *p.* 361). *The present patent refers to the use of these substances in a cupola, for the production of a sort of decarburized pig iron to be further decarburized into steel.*

The employment of chrome is first specified in this patent. Its function here is obviously that of a flux.

THE USE OF STEAM IN THE FINERY OR PUDDLING FURNACE.

GUEST, Sir JOHN JOSIAH, and EVANS, THOMAS.—1840. May 28. No. 8,518.

"Improvements in manufacturing iron," &c. The invention consists in introducing steam into the refinery or puddling furnace, "forced upon, or into, or in contact with the metal. Any suitable means may be employed. The specification and drawings describe furnaces having telescopic injection tubes.

[Printed, 9d. See "Repertory of Arts," vol. 16 (new series), p. 281; "London Journal" (Newton's), vol. 21 (conjoined series), p. 447; "Mechanics' Magazine," vol. 33, p. 381; "Inventors' Advocate," vol. 3, p. 23; and "Engineers and Architects' Journal," vol 3, p. 396.]

NOTE.—*This is the first mention of the use of steam in connection with the purification of iron.*

PUDDLING FURNACE — PUDDLING WITH ANTHRACITE COAL.

COOPER, THOS., New York.—1840. Aug. 25. Reissued.—1841. March 18. (U. S.)

NOTE.—*No specification published.*

THE FINERY AND PUDDLING FURNACE CONNECTED, SO AS TO RUN LIQUID METAL FROM THE FORMER INTO THE LATTER.

BOOKER, THOMAS.—1841. Feb. 22. No. 8,855.

"Improvements in the manufacture of iron." These consist in making a connection between the finery and the puddling furnaces, which may be of any suitable construction so that "the heated metal from the refinery furnace" may be run or passed into the puddling furnace, without being first permitted to cool.

[Printed, 9d. See "Repertory of Arts," vol. 17 (new series), p. 27; "London Journal" (Newton's), vol. 21 (conjoined series), p. 107; "Mechanics' Magazine," vol. 35, p. 208; "Inventors' Advocate," vol. 5, p. 134; "Transactions of Society of Arts," vol. 54, p. 25; and "Engineers and Architects' Journal," vol. 7, p. 76.]

THE FINERY AND BOILING PROCESSES AT ONE OPERATION.

POWELL, LANCELOT, and ELLIS, ROBERT.—1841. April 24. No. 8,935.

"Improvements in manufacturing iron." The construction and operations of the refining, puddling and boiling furnaces are described as known before the date of the patent. The improved process consists in bringing iron, while in a molten state, from the blast furnace direct to the boiling furnace, and there subjecting it to the action of streams of blast or atmospheric air directed upon the metal while the boiling process is going forward. With a charge of four and a half hundredweight of iron (from Welsh ores) a stream of air introduced through "a pipe of one inch diameter, with a pressure of one and a half to two pounds on the square inch, leads to a beneficial result."

[Printed, 4d. See "London Journal" (Newton's), vol. 21 (conjoined series), p. 33; "Mechanics' Magazine," vol. 35, p. 366; and "Inventors' Advocate," vol. 5, p. 277; Patent No. 1,370.]

PIG IRON SOAKED IN WATER—MELTED IRON RUN INTO WATER, TO WHITEN AND PURIFY IT.

GREGORY, JAMES, and GREEN, WILLIAM.—1841. May 14. No. 8,959.

"Improvements in the manufacture of iron and steel." These consist in submitting the crude pig iron to the action of water. The iron, in the form of pigs, or broken small, is immersed in water, and allowed to remain exposed to its action "until there is no longer any change produced upon it; a period of from two to three weeks is generally sufficient for this purpose. The appearance of an oily looking scum on the surface of the water indicates that the water has produced its full effect upon the iron." Running water may be used, but standing water is preferred, as its scum indicates when the operation is completed. This process "causes the iron to become softer and tougher." If the iron is required to be of "close texture of that kind called brittle iron," it is to be heated to a bright red heat, and submitted to the action of cold water by sprinkling or immersion. If the iron be of impure quality it is fused in a "finery." Iron so treated is superior for casting and for conversion into wrought iron. The improved process for refining, which may be used alone, or in conjunction with that just described, is as follows: The iron is melted "in a reverberatory or other suitable furnace," and then poured, "while in its melted state, through a vessel, the bottom of which is perforated with holes about one-quarter inch in diameter, lined with clay. The fused metal is received in a vessel of cold water," of any size; by preference it should be so deep "that the drops of metal may be well cooled." Iron is considerably refined by this operation; it "possesses a close texture, and is of a white color," and is "much better adapted for conversion into steel than the iron manufactured in the ordinary method."

[Printed, 3d. See "London Journal" (Newton's), vol. 21 (conjoined series), p. 34; "Mechanics' Magazine," vol. 35, p. 413; and "Inventors' Advocate," vol. 5, p. 324 See Patents, Nos. 759, 4,151.]

BRIDGE CONSTRUCTION.

The principles and practice in modern iron bridge construction are thus mentioned in "Engineering": Little that is new in principle has been achieved during the last year. Wrought iron arches, where arches are employed at all, are certainly coming into increasing favor. The widest wrought iron arch yet constructed is that of the Pont d'Arcole, in Paris, 262 ft. in clear span. A somewhat later example was that of the bridge over the Thiess, at Szegedin, in Hungary, and Mr. Fowler was the first to adopt wrought iron arches in England, viz., in his fine railway bridge, of four 175 ft. spans, across the Thames, at Pimlico. Mr. Fowler has attempted, experimentally, with great success, to construct a large concrete arch, with a view to the application of the system in his practice. On the Continent concrete voussoirs are sometimes employed, and the attainment of a monolithic arched bridge, of considerable span, is not beyond the resisting powers of the material.

Engineers should examine fully into Mr. Sedley's proposed system of double cantilevers with an arched or trussed span placed between them. It secures a very considerable economy of material in long spans. Mr. Sedley not long since tendered for the construction of the great Moerdyk bridge, which he proposed to complete in eleven spans of 400 ft. each, on an estimate of between £600,000 and £700,000.

It is desirable also to inquire if more than one tension member is necessary in trussed bridges carrying their load on the level of the upper booms. We last week illustrated a Norwegian bridge of triangular section, only one tension member being provided for the two booms in compression. So, too, the great (455 ft.) spans of the Saltash bridge have each but one compression member, and we may note that in his design for the Kentucky railway suspension bridge, of 1,224 ft. clear span, Mr. Roebling proposed to employ a single stiffening girder of timber beneath the roadway.

When rolled rings, requiring no riveting, are once produced upon a commercial scale, it is probable that engineers will introduce new forms of compression members in all trussed structures, the circular strut being far stiffer for a given weight of iron than the cruciform section obtained by riveting up T or angle iron.

There is a greater tendency towards pin jointing in trussed girders, as distinguished from the clumsy mode of riveting the parts together. Warren's girders have always been made with turned pin joints, as are the joints of all chain suspension bridges, and Mr. Hawkshaw has employed turned pins instead of rivets to a very considerable extent, as in his Charing Cross and Londonderry bridges. In America, Fink's, Bollman's, and the Murphy-Whipple iron bridges are all made with turned pins.

But, after all, there is less to be said of the structure than of the appearance of our bridges. When shall we have engineering science wedded to true architecture, as in the case of Mr. Page's fine bridges, and in those, worthy a superior age, constructed by Mr. Joseph Mitchell upon the line of the Highland Railway? The latter, taking their abutments and piers along with their girders, are the finest railway bridges ever constructed, except with arches. Too many, far too many, of our engineers take a pride in ugliness, and perpetrate it wilfully. The time will come when offended taste will cry out and demand the demolition of their ugly works, and we shall not be surprised if the time is soon. Bridge work should no longer be all calculation and contract, but be redeemed by the graces which refined minds are always so ready to lavish upon structures of far less publicity and importance.

THE "ROUND OAK" COAL AND IRON WORKS.

Mr. Samuel Griffiths, in the "Birmingham Daily Gazette."

The Earl of Dudley's iron works at Round Oak are situated on the high road between Dudley and Brierly Hill, and are, without doubt, the most complete in South Staffordshire, regularly turning out a quality of iron unrivalled by, if not superior to, the production of any works in the Black Country. We arrive at this great establishment by the West Midland division of the Great Western Railway, which runs parallel with one angle of the works. A canal connects it with the North-Western Railway, and 12 locomotive engines are employed to serve these works, thereby rendering assistance also over 40 miles of railway, which traverse his lordship's collieries. The works, together with the offices, etc., cover 30 acres of land, and they are capable of turning out from 500 to 550 tons of best finished iron per week. There are nine steam engines in the mills and forges, all working vertically or horizontally, and a very large steam hammer, with the last improvements, which is capable alike of dropping a 20-ton blow or cracking a nut without bursting the kernel. Here they have four large forge hammers or helves, and this is the only method adopted to form the puddled balls into blooms or slabs, as they may be required. Old fashioned shingling is the practice here; neither squeezers nor patent shingling of any kind is resorted to.

There are five rolling mills—one 16 in. plate mill, a 12 in. ditto, an 8 in. and 7 in. bar mill, with a good hoop mill; and the space allotted to the hoop mill and the fencing wire mill—indeed, all the mills in these works—is admirable for its extent and convenience. The speeds are higher than anything in South Staffordshire, and the machinery, by its quiet and steady motion, forcibly reminds one of the regularity of clock-work. We have no hesitation in saying that the construction and perfection of the gear which drives all the mills and forges supersedes anything we have seen in this or any other country. The wheels, when in full work, make very little noise; the driving wheels are large, and as the engines run fast, the nut on the fly shaft of necessity is very rapid, but the sound resembles the gentle murmur of the crabwood gearing of a flour mill rather than the unremitting contact of metal with metal in their constant revolutions. We hear no banging sounds like a sledge hammer on the cog of a wheel, which are generally heard in the iron works of the Black Country. We were much struck with the truth of all the driving wheels; indeed, the general lines of the work reminded us of a parallel, always square and rightly placed. We could not help observing the scientific distribution of metal in the numerous wheels and shafts. Even those unwieldy blocks of metal called cam-rings were shaped with a view to a scientific distribution of the iron, and the engineer, while exercising economy in this respect, had not forgotten the ornate. There are 53 puddling furnaces, nine ball furnaces and two heating furnaces. The fettling used is ground bull-dog only. Neither pottery-mine nor hematite ore is permitted in the works.

The bull-dog is calcined exclusively from the taps of the puddling furnaces on the spot. The puddling furnaces are fixed at equi-distance from the hammers, and as the interior area is completely laid with square plates, the roofing being sustained by a very high wall plating on columns all round, the works present a clean and comfortable aspect, and must be comparatively cool in summer time, which is a great desideratum. A railway serves the coal and removes the ashes from the back, while a second railway deposits the pig-iron and ground bull-dog on the standings at the front of the furnaces. The kilns for calcining bull-dog are fixed at equi-distance between both works, and a railway takes the taps from the works to the kilns, returning loaded with the ground fettling for the puddling furnaces, which struck the writer as a very perfect and economic arrangement for this otherwise dirty and expensive process. The last erections here are the new forges, situated a few hundred yards from the old mills, containing 28 puddling furnaces, fixed round the works in the shape of a horse-shoe, being ministered to by two large forge hammers, which are driven by two vertical engines 55-horse power each, each engine driving a hammer, forge rolls, &c., *per se*, so that the motive power of the one is disconnected with, and independent of, the other; the engines, driving wheels, rolls, &c., being fixed parallel with the heels of the horse-shoe figure of the forges, a space is left between the driving wheels, and the engines being fixed underground, but everything as firm as a solid rock. The puddling furnaces are served with coal, metal, &c., by rail, back and front, as described above, and the puddled bars, billets, &c., are removed by rail, with locomotives, into the mills, which are at some little distance, for consumption.

It must be observed that the whole of the pig-iron or plate-iron consumed is made from the Earl of Dudley's mines, raised on the estate, and smelted at his own blast furnaces. Nothing is used but his lordship's ten-yard coal, which is doubtless the best in the world for the manufacture of iron. No foreign pigs of any kind are permitted in the works, hence the famous quality of the iron produced. These great works are justly famed for the manufacture of large rounds and squares. Rounds are rolled here as high as six and a half inches diameter down to seven-wire gauge; and the higher sizes of rounds are in general request at the machine shops of the kingdom for piston rods, owing to the compactness and superior quality of the iron rolled here. Boiler plates are made with facility, of large size, up to 18 cwt.; angle bars and T-iron of great length are made, from 6 in. by 6 in. to $\frac{3}{4}$ in. by $\frac{3}{4}$ in. flats of all thicknesses, from 12 in. down to $\frac{1}{2}$ in. wide; an unequal size of angle iron, from 8 in. by $2\frac{1}{2}$ in. down to 2 in. by 1 in.; likewise channel iron, from $3\frac{1}{4}$ in. to $\frac{3}{4}$ in.; glan iron, ovals, round-edged flats, core bar iron, bevel iron; Z-iron, or, in other words, double-angle iron; square-edged and feather-edged iron, boat-guard iron, shutter iron, great bar iron, with various other specialities too numerous to mention. Here likewise the famous U-iron is produced, which up to this time has not been rolled at any other works in England. Rails of a very superior quality are likewise manufactured here, for the rolling of which the works offer great facilities. A layer of steel is welded on the top of the rail, the web or foot being made of his lordship's best fibrous iron, which is said to give greater strength and durability to the rail than the steel rail made in other districts.

The Earl of Dudley's iron stands quite at the top of the Staffordshire makes, and possesses all those peculiar qualities which have rendered Staffordshire iron so famous throughout the world in a more eminent degree than any other maker. This mainly arises from two causes—first, the splendid ten-yard coal, so abundant in his lordship's estates; and, secondly, the superiority of the earl's argillaceous iron-stones found west of Dudley. The iron produced here is consumed by shovel and spade makers (in plating bars), for horse-shoes, rivet-iron, cotton rollers, gun barrels, bayonet iron, saddlers' iron-mongery, for wire-drawing purposes, locomotive engines, and agricultural machinists' purposes. Its tension while hot in punching is marvellous. It is likewise used for all bright work, easily polishing without specks, and for other specialities, which renders its adoption desirable where it can be obtained.

The Earl of Dudley's finished iron is largely consumed at the great engine shops on the banks of the Neva, in Russia, and is sent to Canton, Foo-chow-foo, and Pekin, in China; to Hokudadi and Yokohoma, in Japan; Cabul and Candahar, in Affghanistan; and even the almost unexplored regions of Thibet are supplied, via Cashmere, with some particular kinds of iron from these famous works; and pig-iron with his lordship's brand was found in Theodore's cannon foundry in Abyssinia, which must have been carried for some hundreds of miles on the backs of the attenuated mules of that country. The superiority of this marvellous iron is owing, no doubt, to three or four circumstances. In the first place, all other makers buy different mixtures of pig-iron. The Earl of Dudley makes at his blast furnace establishment the best iron that can be made out of the materials raised in his own estates, and consumes these pigs, and no others, at the Round Oak Works.

The Round Oak Works were founded by the late Mr. Richard Smith, who for thirty years was faithfully and successfully engaged in developing his lordship's coal and mineral empire. The tact, talent, and business abilities of the late lamented Mr. Smith were well known and appreciated in the iron trade. Mr. Frederick Smith, the present manager, is a gentleman and a scholar, a Fellow of St. John's, Oxford, but obtained immense practical knowledge under the guidance of his late father; and as he inherits the business qualities of his father, the efficiency of the management continues unabated. Probably a greater willingness is evinced to adopt all modern improvements and adapt these great manufacturing operations to the requirements of the day, keeping abreast in all departments with the rapid progress of the iron age in which we live.

NAVAL ENGINEERING.—At the late meeting of the Institution of Naval Architects, many important papers were read, abstracts of which will appear in these pages.

HYDROGEN AS AN ILLUMINATING GAS.

From the "Mechanics' Magazine."

In every process, chemical or mechanical, a certain amount of loss or waste of either material or power must take place. The results obtained by a chemical process never coincide exactly with the theoretical formula, nor, mechanically, can the work done ever equal the power applied. An ignorance, or, what is worse, a culpable neglect of these fundamental principles, has led scientific fanatics to spend their time, money, and ultimately their lives, in a fruitless search after the impossible. The loss accruing to ordinary gas, from the very commencement of its manufacture, to the moment that it flows from the burners, as a source of illumination, is occasioned by both chemical and mechanical unavoidable imperfections. The latter is caused by leakage, owing chiefly to defective joints, unsound pipes and the carelessness of those who are concerned in its manipulation and distribution. The former is due to chemical action solely, and could scarcely be prevented, which is not the case with the other sources of loss. About fourteen per cent may be taken as the average loss incurred in the manufacture and burning of ordinary gas, or that which represents the actual discrepancy between the theoretical and practical results. The composition of ordinary gas consists mainly of carbureted hydrogen gases; and as hydrogen itself possesses no power whatever of illumination or brilliancy, it is not, at first sight, quite obvious what advantage results from its presence. Any-one who has dabbled in elementary chemistry is aware that hydrogen gas, when tolerably pure, burns with a pale blue flame, emitting little or no light, but endowed with a very high temperature. At the same time, by causing its high temperature to act upon other bodies, such as platinum and lime, it develops a flame of great beauty and brilliancy. To a similar cause is due the illuminating properties of ordinary gas. The action of the high temperature of the burning hydrogen upon infinitesimal particles of carbon renders them incandescent, and imparts to the gas its powers of illumination. Hydrogen, therefore, destitute of brilliancy when pure, becomes possessed of that property when in mechanical combination with carbon—in other words, when it is carbureted. If it were possible to bestow upon hydrogen illuminating properties without carbureting it, as in the ordinary manufacture, the whole process would be rendered much simpler and more economical.

It has been asserted that it would be found a great advantage to employ a much larger proportion of hydrogen in the ordinary gas than what at present prevails; in fact, to constitute it rather a hydrogen gas than that of which it is now composed. A very large proportion of hydrogen is lost in the manufacturing process, which might be easily preserved and utilized, resulting in the production of a gas of a superior quality. The same may be stated with respect to other volatile and illuminating ingredients, including the paraffin and benzine, which, for the most part, are left in the bye products. Were hydrogen more carefully sought for and preserved in the manufacture of gas, the volume would be considerably increased, in addition to a greater purity being imparted to the product. It is notorious that the ordinary gas, in many of the smaller towns, is so impure, and possessed of so small an il uminating power, that many persons refuse to have it laid on to their premises. A gas composed mainly of hydrogen would be free from most of the noxious and disagreeable properties unquestionably possessed by our present great source of public illumination, but until it can be demonstrated that a better gas can be supplied at the same rate, we shall, as usual in such matters, stick to the old plan of manufacture.

IMPROVEMENT IN PUDDLING.

FINE ORE STIRRED IN WITH THE CHARGE.

The remarkable results of the Ellerhausen process—mixing 30 to 33⅓ per cent of fine ore with pig iron, previous to its treatment in the puddling furnace, has led to a number of experiments in a similar direction. One of the most important of these experiments was recently made at the works of Messrs. Henry Burden & Sons, Troy, and consisted in melting the pig iron in a puddling furnace fettled with about half the usual quantity of lump ore, scattering over the iron and stirring into it 30 per cent of fine ore, lowering the heat slightly to give the iron and ore time for reaction, and then raising the heat and balling the charge in the usual manner, but with a saving of some 30 per cent in time and an improvement in quality of product. This treatment was clearly pointed out, in kind, but not in degree, by David Mushet, 34 years ago.* The results given below were furnished by Messrs. Burden for the public benefit, and were ascertained with great care and accuracy.

Record of Experiment at Nos. 10 *and* 12 *Single Puddling Furnaces, "Burden Iron Works," week ending* 20*th Feb.*, 1869, *charging* 448 *lbs. of Pig Iron to each heat, and using* 30 *per cent. Fine Ore.*

No. 10 FURNACE.

MATERIAL CHARGED.

DATE. — 1869.	Turn.	Pig iron charged.	Coal.	Fettling ore.	Fine ore.	Iron made.	Heats.
Feb. 15...	Night.	3,584	6,000	3,425	1,072	3.620	8
16...	Day.	3,584	6,800	2,000	1,072	3,688	8
	Night.	3,584	.....	.....	1,072	3,756	8
17...	Day.	3,584	6,400	1,500	1,072	3,648	8
	Night.	3,584	.....	.....	1,072	3,500	8
18...	Day.	3,584	7,200	1,000	1,072	3,562	8
	Night.	3,584	.....	.....	1,072	3,610	8
19...	Day.	3,584	6,800	2,000	1,072	3,582	8
	Night.	3,584	.....	.....	1,072	3,935	8
Sat. 20 ..	Day.	1,792	1,600	.....	536	1,852	4
		34,048	34,800	9,925	10,184	35,053	76

No. 12 FURNACE.

MATERIAL CHARGED.

DATE. — 1869.	Turn.	Pig iron charged.	Coal.	Fettling ore.	Fine ore.	Iron made.	Heats.
Feb. 15...	Night	3,584	6,200	3,220	1,072	3,836	8
16...	Day.	3,584	6,800	2,300	1,072	3,820	8
	Night.	3,584	.....	.....	1,072	3,917	8
17...	Day.	3,584	6,800	2,000	1,072	3,610	8
	Night.	3,584	.....	.....	1,072	3,698	8
18...	Day.	3,584	6,800	2,000	1,072	3,736	8
	Night.	3,584	.....	.....	1,072	3,762	8
19...	Day.	3,584	7,200	2,000	1,072	3,682	8
	Night.	3,581	.....	.....	1,072	3,642	8
Sat. 20...	Day.	2,240	1,600	.....	670	2,300	5
		34,496	35,400	11,720	10,318	36,003	77

SUMMARY OF RESULTS.

Old System Puddling.	*New System Puddling.*
Coal consumed per ton of puddled bars ....2,698 lbs.	Coal consumed per ton of puddled bars ....2,213 lbs.
Fettling ore consumed per ton of puddled bars ......1,374.	Fettling ore consumed per ton of puddled bars.....682 lbs.
Average turn six heats, 2,667 lbs.	Fine ore consumed per ton of puddled bars.......646 lbs.
No waste.	Av. turn eight heats, 3,552 lbs.

Saving by new system in coal per ton of puddled bars over old system.. 485 lbs.

Increase in consumption of ore per ton of puddled bars over old system........................ 46 lbs.

Increase in product of puddling furnace over old system.. 34 per cent.

Gain in yield of both furnaces over old system during the week........................ 2,512 lbs.

LIGHT RAILWAYS.—Mr. Zerah Colburn is preparing a very comprehensive paper on this subject, to be read before the Institution of Civil Engineers.

* See Van Nostrand's Magazine, No. 4, page 361.

IRON AND STEEL NOTES.

STRENGTH OF STEEL VARIOUSLY CARBURIZED.—The following tables are from a list of experiments made by Mr. Thomas E. Vickers, of Sheffield:

Softest, or least carbonized steel containing .33 per cent carbon, marked No. 2. The hardest, or most highly carbonized, containing 1.25 per cent carbon, No. 20; the intermediate numbers representing intermediate degrees of carbonization.

TENSILE STRENGTH.

Description of steel.	Proportion of carbon. (Approxi.)	Breaking strain per square in.	Elongation.	Specific gravity.
No.	Per ct.	Tons.	Inches.	
2	0.33	3.4	1.37	7.871
4	0.43	34.0	1.37	7.867
5	0.48	37.5	1.25	7.855
6	0.53	42.5	1.12	7.855
7	0.58	41.5	0.81	7.852
8	0 63	45.0	1.00	7.848
10	0.74	45.5	0.69	7.847
12	0.84	55.0	1.12	7.840
15	1.00	60.0	1.00	7.836
20	1.25	69.0	0.63	7.823

Tensile strength is increased by the addition of carbon until the steel contains 1.25 per cent, when it sustains about 69 tons per square inch; beyond this degree of carbonization the steel becomes weaker, until it reaches the form of cast iron.

Transverse Strength of Axles.—Axles turned to 3.94 inches diameter at center, 3.25 at the ends, placed on bearings three feet apart; ram weighed 1,547 lbs.; dropped on center of axle from height of one foot, increasing up to 36 feet fall.

Materlal of axle.	Proportion of carbon. (Approximate.)	Total number blows.	Height of fall in last blow.	No. of blows sustained from 36 feet high.	Sum of deflection.
	Per ot.		Ft.		Inch.
Steel No. 2	0.33	17	36	4	58.81
Steel No. 4	0.43	18	36	5	56.00
Steel No. 5	0.48	18	36	5	53.56
Steel No. 6	0.53	15	36	2	35.06
Steel No. 7	0.58	16	36	3	38.81
Steel No. 8	0.63	18	36	5	46.00
Steel No. 10	0.74	16	36	3	40.31
Steel No. 12	0.84	10	20	..	8.56
Steel No. 15	1.00	8	12½	..	4.31
Steel No. 20.	1.25	10	20	..	6.94
Best wrought iron	....	13*	36	..	31.19
Scrap iron	....	5	5	..	2.00
Scrap iron	....	5†	5	..	3.69

CONSTRUCTION OF BLAST FURNACES.—An interesting and instructive experiment bearing upon the construction of blast furnaces, has recently been made at the "Consett Iron Works," at Durham, England. The Consett Iron Company smelt each year about 200,000 tons of ore in four blast furnaces. At present the waste gases are only taken from one furnace, on the bell and hopper system, but one of the furnaces is being altered so that the waste gases can be taken off on a modification of the side flue system, a little novel in character. The blast is heated just now to 1,000 degrees by a couple of ∩ cast-iron pipe stoves. These are to be removed, and four stoves on Whitwell's principle substituted, from which the best results are anticipated. Mr. Radcliffe, the superintendent, believes that the extraordinary results obtained from the high and large furnaces now popular in the Cleveland District are due not so much to the dimensions of the furnace as to the excessively high temperature of blast with which they are worked, and is inclined to the opinion that the proper capacity of furnaces has been overstepped, and cites the following interesting fact in support of his theory. Some time since it was decided that a new furnace should be erected at Consett, with a height of seventy feet.—It was built and worked for some time; but the yield per ton of coke and the quality of iron were both found to be inferior to the yield and quality from the other and smaller furnaces. The furnace worked on Cleveland and hematite ore with a very good and clean coke quite capable of carrying the burden. It was then determined to cut the furnace down to a height of fifty-five feet, and the result was eminently satisfactory; the yield and quality were greatly improved, and the furnace is now one of the very best in the district. The blast is supplied by two high-pressure engines of an old type, with six feet six inches blowing cylinder, nine feet stroke, and a supplementary engine, which also drives a pair of plate rolls. The waste gases are used to raise steam in a magnificent set of new boilers, six in number, each 70 feet long, egg-shaped, with a diameter of 3 feet 10 inches. They are set in a very peculiar way. Cast-iron columns are erected on the brick-work in which they are set, and on these are supported five cast iron girders running across the tier of boilers.

From these girders depend sling stays, which are secured to double angle iron semi-circular rings riveted to the upper side of the boilers. A straight flue, 70 feet long, runs the whole length of the boiler below, right to the stack. The stack in connection with these boilers is 250 feet high, and 24 feet diameter inside at the base.—*Bulletin Am. I. & S. Ass'n.*

PHOSPHORUS IN CAST-IRON.—While the question of phosphorus and its effects on iron is being discussed, the following method of examination employed by a French metallurgist, M. V. Tantin, deserves notice.

M. Tantin says: "It is well known that very small quantities of phosphorus produce no sensible alteration in the quality of cast iron, whereas if the proportion exceeds a few thousandth parts the iron is robbed of its most essential qualities. It is very important, therefore, to ascertain the exact amount of phosphorus present. Nearly all the methods in use for this purpose consist in treating the iron by means of oxidizing agents, so as to cause the phosphorus to pass into the condition of phosphoric acid, which is precipitated in the state of a magnesian compound.—Several causes of error exist in this treatment, for (1.) a part af the phosphorus escapes the action of the agents, and disengages itself in the form of an hydrogenous compound. (2.) It is necessary to act upon very diluted solutions to prevent the ammoniacal-magnesian phosphate mixing with the oxide of iron, in which case it is difficult to collect the small amount of phosphate deposited in the sides of the vessel in which the precipitate is made. (3.) The arsenic which may be contained in the iron enters into the magnesian precipitate in the form of arseniate as insoluble as the phosphate.

* Cracks began to show at 10 lb. blow, with 20 feet height of fall, and increased with each such subsequent blow.

† Two large cracks opened at five pound blow, and considered as broken.

"In order to avoid these objections, I tried to attain my object by a directly opposite road, that is to say, in disengaging the phosphorus in the form of an hydrogenous compound, but then arose the question whether the whole of the phosphorus passed into the form of a gaseous product. This was, however, proved by the fact that no trace of phosphorus was ever to be found in the residuum after the iron had been completely acted upon by hydrochloric acid. This result ought to cause no surprise, considering the very energetic affinity which phosphorus has for hydrogen. The phosphureted hydrogen produced by the action of hydrochloric acid on iron is almost always accompanied by sulphureted, arseniated, and carbonated hydrogen. In order to effect the separation of these gases, they may be made to pass first through a Wolf's bottle containing a solution of potash, which absorbs the sulphureted hydrogen; then through a solution of nitrate of silver, which transforms the arseniated hydrogen into arsenite of silver soluble in the liquid becomes slightly acid, while phosphureted hydrogen precipitates the argentine solution and forms insoluble phosphorus.—The phosphorus being thus absolutely separated from the sulphur and the arsenic, its amount is ascertained with the greatest ease; the phosphure of silver is treated with nitro-muriatic acid, and thus transformed into chlorure of silver and phosphoric acid, which is precipitated in the form of ammoniacal-magnesian phosphate. This precipitate, when calcined, gives the proportion of the phosphorus to the iron.

"In order to obtain the whole of the phosphorus the following precautions must be observed: Let the iron be attacked gradually, otherwise a portion of the phosphureted hydrogen may traverse the solution of nitrate of silver without being absorbed. And when the action on the iron is finished, pass through the apparatus a stream of hydrogen which has previously been washed in acetate of lead.

"The solution of potash contains all the sulphur which was present in the iron treated, and in order to ascertain the quantity of that substance the solution must be treated with acetate of lead; the precipitate produced is at first a mixture of oxide and sulphite of lead, but the oxide is soon redissolved and the sulphite still remains. The precipitate must be collected in a filter, washed with distilled water, and completely dried before being weighed."—*The Engineer.*

THE SIEMENS-MARTIN PROCESS.—The "Mining Journal" says that Mr. Bernard Samuelson, M. P., has erected extensive works at Newport and South Stockton, for the manufacture, on a very large scale, of rails, angles, plates and sheets, by this process. Richardson and Johnson's process of purification, will be used in the preliminary processes, and Siemens' furnaces for heating, &c., are to be employed throughout.

EXTENT OF THE BESSEMER MANUFACTURE ON THE CONTINENT.—There are now in use in Europe, Italy and Russia excepted, 128 Bessemer converters, these having a total capacity of 555 tons. Krupp is the largest owner of Bessemer converters, there being thirteen at the Essen works, some of them having a capacity of seven tons. In France 20,000 tons of Bessemer steel were made in 1867, and 35,000 tons in 1868.

WATER BOSHES FOR CUPALAS.—In the "Mechanic's Magazine" of February 12. 1869, this construction, as patented by Mr. John Thomas, of Newcastle-on-Tyne, is fully illustrated and described. The object is to prevent the excessive wear of bricks. The water boshes are covered on the inside with spikes, like a founder's loam plate, by which the refractory lining is held in place.

NEW METHOD OF PILING LARGE ARMOR PLATES.—An experiment in rolling large armor plates was recently made at the works of Sir John Brown & Co. The plate manufactured and finished is 12 ft. 8 in. long, 8 ft. 6 in. wide, and 5 in. thick. The difficulty experienced in producing large plates has hitherto been in heating sufficient wide piles in the furnace, and in thoroughly driving out the slag and cinder, which would become incorporated in the plate. By the process of Mr. Ellis, the managing director of the company, the piles are built up comparatively narrow, and are passed through the rolls until the length of the mass becomes equal to the finished breadth of the plate. The pile is then turned and rolled out in the direction of its breadth, until the required length and thickness is attained. The pile from which the plate was constructed was built up of five slabs, each 7 ft. by 6 ft., and 3¼ in. thick, weighing 14 tons, and was heated for sixteen hours previous to rolling, which operation occupied three-quarters of an hour from the time when the pile was withdrawn from the furnace. The successful issue of this experiment promises a great advance in the manufacture of large armor plates; and the difficulty of dealing with piles being avoided, plates 8 ft. wide, and not only 12 ft., but 20 ft. or 30 ft. long, can be produced by the method of Mr. Ellis.—*Engineering.*

CONTINENTAL COMPETITION WITH ENGLAND.—Belgium and France often obtain considerable orders from the Russian and Austrian railways. The plan adopted in Belgium is to form a committee of ironmasters, who appoint one of their number to tender for any large contracts that may be offered. He proceeds to the spot, and works for the interest of all the makers of rails in Belgium; the ironmasters decide upon the terms which he may offer, and the orders are divided among them pro rata of their means of production. Payment being very often made by bills or guarantees, which individual firms could not accept without danger, a financial association supports the operations of the committee; by these means the risk is divided amongst a large number of individuals, and when losses are made they are less heavy, from being divided. Our authority also has the following: The English railmakers formerly supplied the greater part of the steel rails required for the American railways; now the French houses seem to threaten formidable competition. MM. Petin-Gaudet et Cie. have, it is said, recently supplied 5,100 tons of steel rails to the New York Central Railway Company, and considerable quantities to other companies.—*Journal des Travaux Publics.*

BLAST FURNACE SLAG FOR BUILDING AND PAVING.—The following method is now adopted in several iron works in Belgium: The slag is allowed to run direct from the furnace into pits about eight or nine feet in diameter at the top, with sides sloping inwards towards the center, where they are about three feet deep. The mass is left for eight or nine days to cool, when a hard, campact, crystalline stone is obtained, which is quarried and used for building purposes, but chiefly for paving-stones. They appear to wear exceedingly well, being quite equal to the grits and sandstones already so much used.

EXPANSION OF IRON DURING COOLING.—It is stated in the "Scientific Review" that Mr. Gore, of Birmingham, whilst making some experiments on heating a strained iron wire to redness by means of a current of voltaic electricity, has observed that on disconnecting the battery, and allowing the wire to cool, during the process of cooling the wire suddenly elongated, and then gradually shortened until it became quite cold. No explanation of the action has, so far as we are aware, been advanced.

ORDNANCE AND NAVAL NOTES.

Krupp's New Eleven-Inch Guns for Russia.—About five years ago, when the Russian artillery made use of muzzle-loading rifled cannon, the Russian government had ordered of M. Krupp a cast-steel gun on that system, rifled 11-inch bore, English measure. Since then, numerous experiments having been considered to prove the superiority of breech-loading guns throwing projectiles larger than the bore, the Russian artillery has decided on adopting these guns exclusively. At the time of this decision the 11-inch was in a forward state of manufacture as a muzzle-loader, and when its conversion was contemplated, there was reason to fear that the walls of the gun would be too thin for the slot for the breech-piece; but further experiments on the resistance of breeches of different thicknesses having demonstrated the possibility, the alteration to a breech-loader on Krupp's principle was made. This gun has been subjected to a prolonged trial of 400 rounds, the number fixed by the Russian authorities. The details of the gun are:—Total length of bore, 160.2 English inches; length of rifling, 113 in.; number of grooves, 36; weight of gun, 25 tons, 11 cwt. 3q. 3 lb. The weight of the projectile is 496 lb.; the weight of the charge, 82½ lb. of Russian prismatic powder. The initial velocity communicated by this charge to this projectile was 1,308 ft. The gun stood the 400 rounds with this charge, and remained in a serviceable condition. The above quantities, as well as those which follow, are all in English measure, the equivalents having been reduced from the Prussian denominations.

The breech-piece was Krupp's single round wedge. Two were furnished for the experiments, one having a Rodman knife apparatus for measuring the pressure of the gas in the chamber, and which was only used for that purpose; the other an ordinary breech-piece intended for the endurance trial. This breech-piece, in this experimental practice, worked throughout with the greatest ease, and all escape of gas was perfectly prevented by one Broadwell ring, which sufficed for the whole number of rounds. The explosion of the charge took place in the direction of the axis of the bore, ignition having been effected by a vent through the breech-piece. The gun was sponged out after every 30 rounds, but care being always taken to lubricate the lead coatings of the projectiles there was not the slightest appearance of leading in the grooves. The gun was sponged with soapy water, which effectively removed the slightest fouling. The guttering formed at the seat of the projectile during the firing by the passage of the gas did not exceed three millimetres in depth at the finish of the trial, and all did not seemingly attain this depth. These channels are larger than those observed after 725 rounds in the Krupp breech-loading 9-inch gun, and this circumstance is attributed to the fact that the 11-inch gun had an ordinary chamber concentric with the bore; whereas all the guns of the new construction—such as the 9-inch gun referred to—have eccentric chambers. The 11-inch gun, having been a muzzle-loader, has not the necessary length of bore for a breech-loader, and the new breech-loading guns of this calibre about to be supplied from Krupp's works will have the bore longer by 2½ calibres, so that the initial velocity communicated to the 496-pounder shot by a charge of 82½ lb. of prismatic powder will be increased to about 1,360 ft. per second. The gun was discharged, as we have said, by a vent through the wedge; but there was another vent on the top of the gun, which was closed by a steel screw, and was not used. The objects of the experiments were to ascertain the charge required to give a shot 550 lb. Russian (496 lb. English) an initial velocity of at least 1,300 ft.; to demonstrate by a trial of endurance that, with the chargo thus arrived at, a Krupp 11-inch breech-loader will stand a greater number of rounds than is required to render it fit for active military service.

With respect to the powder, experiments in Russia and at Essen had shown that the prismatic powder introduced into Russia some years since was very well adapted for attaining a high initial velocity without an excessive strain on the gun, and the Russian government, therefore, sent to Krupp's factory a quantity of this power, manufactured in 1865 at Ochta, for these trials. The factory had also a stock of prismatic powder made by Ritter, of Hamm, in Rhenish Prussia, according to the Russian formula. The cartridge bags were of single cotton stuff, the cartridge forming a regular hexagon, with tiers of 37 prisms; the greatest diameter of the hexagon being 9.65 in., the smallest 8.80 in.; the length of the cartridge without the choke, 27 in. The shot were of solid cast iron, with lead coating. The gun was mounted on a proving carriage with cast-iron sides, which afforded no convenience for loading; the recoil was on an inclined plane, so that the gun, after each round, ran back to nearly its original position. It stood in a roofed place, and the firing was into an earth butt at a distance of about 62½ ft., also roofed over. The initial velocity was taken with Captain Le Boulange's chronograph; the first wire target stood at 18 ft. from the muzzle; the second was 32.9 feet from the first. The target wires were fastened separately to iron frames; their thickness three-eighths of an inch in the front, and a quarter of an inch on the second target; the insulated communicating wires were perfectly protected from the gas when the gun was fired. The average pressure of the gas of 3,209 atmospheres is stated to be far from straining the gun up to its limit of elasticity. Ritter's powder, according to the details of the experiments, appears to try the gun less than the Russian powder. The piece was served by eight men, two of whom had to fetch the cartridges from a magazine 150 metres away. For the sake of the durability of the earth butt the shot were dug out after every 60 or 70 rounds. Between every two days consecutive firing gutta-percha impressions were taken and the chamber measured. The gutterings have not, even after 400 rounds, assumed a character in any way serious to the durability of the gun. The regular breech-piece did duty in the gun during 307 rounds, with a charge of 91 Russian lbs. (82½ lbs. English).

Putting together, for comparison, the results of the trials with Krupp's 9-in. 12-ton gun, with hoops, tried in Russia, his 11-inch gun (26 tons), with hoops (trial at Essen), and our English 12-inch muzzle-loader (trials in England), we have the *vis viva* of the shot in metre tons as follows:

Gun.	Caliber.	Charge.	Shot.	Initial Velocity.	Vis viva. Meter Tons.	Vis viva per Centimeter. of Circumference. Meter Tons.
	in.	lb.	lb.	ft.		
Krupp's b l. 15 tons.	9	46	275	1,340	1060·5	15
Krupp's b.l 26 tons.	11	82½	475	1,353	1975·0	23
English m.l. 24 tons.	12	79	600	1,180	1796·7	19

According to the above formula, Krupp's 26-ton 11-inch breech-loader is a more powerful gun than our 12-inch 24-ton muzzle-loader. The new guns, now making under the Russian contract, will be of rather larger measurements than the converted gun used in the experiments above described. Their details will be: Weight, including breech-piece, 25 tons 11 cwt. 3 qr. 3 lb.; no preponderance at the breech; length over all, 18 ft. 4 in.; rifling—36 grooves, 0.135 in. deep, 0.76 to 0.64 in. wide; width of lands, at chamber, 0.17 in.; of grooves, 0.79 in.; at muzzle, 0.17 in. and 0.32 in.; diameter of bore over the lands, 11 in., over the grooves, 11.40 in.; weight of steel shell loaded, 496 lb.; charge for gun, 82 lb.; initial velocity of projectile, 1,360 ft.—*London Standard.*

STEAM LAUNCHES.—One of the most important parts of the equipment of a ship of war is undoubtedly her boats and their capabilities. In this respect the ships of the English navy, a few years since, were far behind those of France or Russia; but at the present time they are much more efficiently provided than the ships of any other nation. For some time after steam-power was applied for the propulsion of boats attached to ships of the French and Russian navies, our own authorities stood by oars and sails, and when they did follow on the new track it was only done at first in a compromising and bungling kind of way. In their application of steam-power to boats our friends aimed at rendering the boat a kind of miniature despatch tender to the ship, possessing as much speed as could be given by the engine and boiler carrying power of her tonnage, without the usual heavy gun at the bow or stern, and with no great capacity for stowage beyond fuel, but with good towing powers, so that she could take a string of heavily-armed boats into or out of any position that might be desired on a coast at a moderate speed. Our first efforts in the same direction was to place twin-screw engines and boilers in the heavy built steam-launches already attached to our ships, retaining them at the same time in all their original form as gun-carrying boats, with armed crews and stores of shot, shell, masts, sails, oars, water, and provisions, &c.; the clumsy bluff-bowed monsters being, when thus loaded, scarcely able to hold their way against a moderate wind or tide in a river way, and useless altogether for towing purposes.

The fitting out of two surveying-sloops for service in the Chinese and Japanese seas led to the introduction of quite a different class of steamboat into our navy, a type of boat which more nearly approached that adopted in the French and Russian navies in its general principles as simply a despatch and towing-boat, but excelling them greatly in having superior speeds combined with the life-boat principle in the boat's construction, the latter arrangement rendering them unsinkable when filled with water to the gunwale's edge when carrying engine and boiler and a double crew on board. Quite recently also it has been proved that the engines of these boats can be driven noiselessly, a most important desideratum when they may be engaged on reconnoitring or cutting out expeditions; and orders issued from the Admiralty direct that all such boats in future supplied to her Majesty's ships are to be fitted with the engines working on the noiseless principle. The builder to the Admiralty of these steam life-boat launches and pinnaces, Mr. John Samuel White, of East Cowes, Isle of Wight, has sent in to Portsmouth Dockyard during the past week four pinnaces, Nos. 8, 9, 10 and 13, under his contract with the Admiralty, which have since been put through their trials by the officials of the yard, and very satisfactory and successful results obtained. After passing through the water-pressure test, they were finally tried over the measured mile. Nos. 8, 9 and 10 are boats of about 37 ft. between perpendiculars, and are driven by single screw engines of six-horse power nominal. No. 8 was tried at a draught of water of 3 ft. $1\frac{1}{2}$ in. aft, and 2 ft. $4\frac{1}{2}$ in. forward. Her four-bladed common screw had a diameter of 2 ft. $9\frac{1}{2}$ in., a pitch of 4 ft., a length of $6\frac{3}{4}$ in., and an immersion of the upper edge of 1 in. The mean revolutions of the engines were 249.33, and the boat's mean speed 7.986 knots per hour. No. 9 was tried at the same draught of water as No. 8. Her four-bladed common screw had a diameter of 2 ft., a pitch of 4 ft., a length of $6\frac{7}{8}$ in., and an immersion of the upper edge of $2\frac{3}{4}$ in. The mean revolutions of the engines were 244.63, and the boat's mean speed was 7.988 knots per hour. No. 13 was tried at a draught of water of 3 ft. aft and 2 ft. $5\frac{1}{2}$ in. forward. Her four-bladed common screw had a diameter of 2 ft. $5\frac{1}{2}$ in., a pitch of 3 ft. 4 in., a length of $4\frac{7}{8}$ in., and an immersion of the upper edge of $3\frac{3}{4}$ in. The mean revolutions of the engines were 282.66, and the boat's mean speed 7.288 knots per hour. No. 10 was tried at a draught of water of 3 ft. aft and 2 ft. 8 in. forward. Her four-bladed common screw had a diameter of 2 ft. $9\frac{1}{4}$ in., a pitch of 4 ft. 2 in., a length of $6\frac{3}{4}$ in., and an immersion of the upper edge of $1\frac{5}{8}$ in. The mean revolutions of the engines was 249.5, and the boat's mean speed 8.040 knots per hour. It was boisterous weather when all the boats were tried over the measured mile. All four of the boats were very handsome and buoyant in their appearance when under full steam pressure in running over the measured mile.—*Army and Navy Gazette.*

THE VAVASSEUR GUN.—A steel 7-in. muzzle-loading gun, designed and built by Mr. J. Vavasseur, of the London Ordnance Works, Southwark, was recently submitted to a private trial, and, so far as could be judged by the eight rounds fired from it, with highly satisfactory results. The gun is made entirely of Firth's steel, the material from which the A tubes of the Woolwich heavy guns are formed.

The inner tube of the Vavasseur gun is similar to that of a service gun of the same caliber, and is covered for its whole length by an outer tube shrunk over the inner. This ring is in two lengths, the first reaching as far as the chamber, the second protecting the A tube from the chamber to the muzzle. Over the second tier is shrunk a series of steel hoops, which extend towards the muzzle of the gun. The trunnions are of wrought-iron, forged upon a wrought-iron band, which is shrunk over the gun, and the breech is closed by a steel cascable screwed into the end of the second or B tube, which forms the rear of the piece. The entire length is 123 in.; the length of bore is 111 in.; the external diameter at the muzzle is 12 in.; the diameter at the breech is 24.4 in.; the total weight, 5 tons 1 cwt.; the trunnions are so placed as to give a preponderance of $5\frac{1}{4}$ cwt. The rifling has an uniform twist of 1 in 35 calibers, and consists of three ribs, with a flat table one inch wide, and raised from the bore about two-tenths of an inch.

This gun is mounted on a steel carriage weighing 22 cwt., the slides being 12 ft long, and 32 cwt. in weight, making a total of 54 cwt. The recoil is absorbed by a coned disc working within an iron drum, the rotation of which is regulated by an adjustable brake strap, tightened by a screw provided with an index divided into tenths. The disc, which is of iron faced with wood, is placed at the forward end of the slides, and is mounted upon a square-threaded screw shaft, with a pitch of 30 in., and which traverses the whole length midway between the slides. One end of the screw shaft carries the disc, which is 14 in. in diameter and 2 in. wide, and which fits within the drum before mentioned. The under side of the carriage carries beneath it a nut working on the screw shaft. The recoil of the gun incident upon the firing, throws the nut upon the bearing side of the thread, and tightens the disc against the circumscribing drum, absorbing the force of the recoil as the nut traverses down the revolving shaft, with a rapidity regulated by the adjustment of the brake strap.

In running out the gun, the carriage is raised at the rear end upon the rollers off the slides by a handspike, the same motion, by a connecting link, throwing the running-out wheels into gear with a pinion inside the carriage, which works into a slotted rack cut into the side plate of the slide along its whole length. This gearing is worked by hand in the usual manner. So soon as the carriage begins to travel the friction brake is released, so that the disc and drum offer no resistance. When the carriage is xtended its full length it is lowered again on to the slides, and the running-out wheels are thrown out of gear.

The recent trials had for their object the testing of the carriage rather than the gun. The following table gives the results in a condensed form:

	Elevation.		Charge.	Compressor.	Recoil.	
	dog.	min.	lb.		ft.	in.
Round 1	5	3	14	7-10	3	7
" 2	5	3	14	13-20	4	0
" 3	5	3	22	15-20	2	5
" 4	5	3	22	29-40	2	11
" 5	8	0	22	7-10	3	8¼
" 6	8	0	22	7-10	3	6
" 7	8	0	22	7-10	3	4¼
" 8	2	30	22	4-5	1	0

The gun and carriage will be doubtless submitted to official trial, which will help to decide the comparative values of steel and iron as a material for heavy ordnanee. Experience has shown in the tests of the Woolwich guns that a steel tube reinforced strongly by a wrought-iron casing remains serviceable, after its bore has become flawed, and its material considerably weakened, by means of the tensile strength of the surrounding metal, whieh is exerted in the direction of the strain upon the steel tube. The saving of weight in steel ordnance does not represent a corresponding saving in cost. A lengthened experience must decide that a large balance remains in favor of steel as an exclusive material for guns before the Woolwich system of manufacture is superseded.—*Engineering.*

Comparative Casualties of War.—The *Revista Militar*, of Lisbon, contends that the perfecting of firearms, far from increasing the mortality in battles, has, on the contrary, diminished it, and alleges the following instances: At Austerlitz the French lost 14 per cent., and the Austrians and Prussians respectively 14 and 30 per cent. of their soldiers. At Moscow the French loss was 37, while the Russian loss was 44 per cent. At Wagram the casualties were, among the French 13, and amongst the Austrians 14 per cent. At Bautzen the French lost 13, the Russians and Prussians 14 per cent. At Waterloo the losses of the Allies were 31, and of the French 36 per cent. Then comes the contrast. At Magenta the French lost but 7 per cent. of their troops, and the Austrian percentage did not exceed 8, while at Solferino the losses of the combatants were 10 and 8 per cent. It is hardly fair to compare the battle of Murfreesborough with those of regular armies, but according to the report of Gen. Rosencranz, which caused some surprise at the time it was published, 20,000 discharges of cannon put only 728 men *hors de combat*, and out of 2,000,000 musket shots no more than 13,330 took effect. It thus took 27 cannon balls and 150 bullets, or about 252 lb. of metal to disable each soldier.

Trowel Bayonets.—The 200 patent trowel bayonets, which have been making at the Springfield armory, will soon be placed in the hands of troops for trial.

The British Iron-clad Fleet. Its Cost. According to a Parliamentary return just issued, it appears that the number of iron-plated ships afloat is thirty-four; there are also ten building. Of four floating batteries, two are not yet completed for sea. Of the number of armor-clad ships afloat, fourteen have iron hulls; the following are only partially armor-clad, viz: The Black Prince, with 28 guns, tonnage 6,109, horse power 1,250; Warrior, 32 guns, tonnage 6,109, horse-power 1,250; Defence, 16 guns, tonnage 3,720, horse-power 600; Resistance, 16 guns, tonnage 3,710, horse-power 600; Achilles, 26 guns, tonnage 6,121, horse-power 1,250; Hector, 18 guns, tonnage 4,089, horse-power 800; Valiant, 18 guns, tonnage 4,063, horse-power 800; Northumberland, 28 guns, tonnage 6,621, horse-power 1,350; Bellerophon, 15 guns, tonnage 4,270, horse-power 1,000; Hercules, 14 guns, tonnage 5,234, horse-power 1,200; Penelope, 11 guns, tonnage 3,096, horse-power 600; Waterwitch, 2 guns; Viper, 2 guns; Monarch, 7 guns. Five of those afloat with iron hulls are wholly armor-clad, viz: the Minotaur, with 26 guns, tonnage 6,621, horse-power 1,350; Agincourt, 28 guns, tonnage 6,621, horse-power 1,350; Prince Albert, 4 guns; Scorpion, 4 guns; Wivern, 4 guns. The Vixen, with 2 guns, has her hull built of both wood and iron, and is only partially armor-clad. Eight of the ships afloat have wooden hulls, but are wholly armor-clad, viz: the Royal Oak, with 24 guns, tonnage 4,056, horse-power 800; Prince Consort, 24 guns, tonnage 4,045, horse-power 1,000; Caledonia, 24 guns, tonnage 4,125, horse-power 1,000; Ocean, 24 guns, tonnage 4,407, horse-power 1,000; Lord Clyde, 24 guns, tonnage 4,067, horse-power 1,000; Lord Warden, 18 guns, tonnage 4,080, horse-power 1,000; Favorite, 10 guns, tonnage 2,094, horse-power 400; Royal Sovereign, 5 guns, tonnage 3,765, horse-power 800. Six of those afloat have wooden hulls, and are only partially armor-clad, viz: the Royal Alfred, with 18 guns, tonnage 4,068, horse-power 800; Zealous, 20 guns, tonnage 3,716, horse-power 800; Repulse, 12 guns, tonnage 3,749, horse-power 800; Pallas, 8 guns, tonnage 2,372, horse-power 600; Research, 4 guns; Enterprise, 4 guns. This formidable fleet of iron-clads afloat represents in the aggregate 520 guns. Out of the thirty-four vessels afloat thirteen are built on Mr. Reed's plan and five on Captain Coles's turret plan. The first cost of some of the iron vessels now complete, ineluding fittings, but exclusive of incidental and establishment charges, was as follows: Northumberland, £459,109; Minotaur, £452,827; Agincourt, £446,115; Achilles, £444,590; Warrior, £356,990; Black Prince, £357,-993; Bellerophon, £343,076; Prince Albert, £201,613. The cost of some of the wooden vessels was:—Lord Clyde, £273,824; Lord Warden, £316,837; Royal Alfred, £269,370; Ocean, £253,813; Caledonia, £264,658; Prince Consort, £226,995. Of the ten ships building, seven have iron hulls and are only partially armor-clad, viz: the Sultan, with 13 guns, tonnage 5,226, horse-power 1,200; the Captain, 6 guns, tonnage 4,272, horse-power 900; the Iron Duke, 14 guns, tonnage 3,774, horse-power 800; the Audacious, 14 guns, tonnage 3,774, horse power 800; the Invincible, 14 guns, tonnage 3,774, horse-power 800; the Vanguard, 14 guns, tonnage 3,774, horse-power 800; the Hotspur, 2 guns, tonnage 2,637, horse-power 600. The Glatton, with 2 guns, has an iron hull, and is wholly armor-clad. The Swiftsure and the Triumph have their hulls of iron sheathed with wood. They are to carry 14 guns each, with a tonnage for each vessel of 3,893; horse-power 800 each. These ten ships represent in the aggregate 107 guns. Two are to be built on Captain Coles' plan, and eight on Mr. Reed's plan. The estimated first cost of the Captain is £335,000, that of the Audacious £222,657, that of the Invincible £221,757, and that of the Vanguard £249,759. The names of the four floating batteries—three of which have iron hulls and are wholly armor-clad—are the Erebus, with 17 guns; the Terror, with 16 guns; and the Thunderbolt, with 16 guns; the Thunder, with 14 guns, has a wooden hull, but is wholly armor-clad. The first cost of these batteries is thus stated:—Erebus, £82,039; Terror, £80,726; Thunderbolt, £80,230; Thunder, £59,776. The above 48 ships and batteries represent in the aggregate 689 guns, and horse-power of 35,290.

THE WILSON GUN.—A contemporary states that this gun is on the bolt principle, and of the most simple, direct and rapid arrangement. It requires but two movements to open and close the breech for firing; or, in other words, four motions for drill—namely, opening, loading, closing, firing—a bar extractor attached to the body of the bolt withdrawing and ejecting the cartridge-case in the one act of withdrawing the breech bolt. This bolt is fixed in position by a locking, or double lugg handle, situated on its rear end, and having a motion of partial rotation on entering the shoe-cap as the breech is closed. It is thus self-locking and securing; the double luggs engaging with the solid sides of the shoe-cap sustains the bolts firmly against the recoil. The gun has neither external lock, hammer, nor other projections, but the bolt itself contains a piston or striker operated upon by a strong spiral spring, the spring being liberated by the trigger depressing a flat guide or retaining spring placed underneath the shoe. The firing arrangement is very properly supplemented with a trigger stop of exceedingly simple and effective construction—namely, a hinged flap or plate, which, turned against the shank of the trigger, absolutely prevents its movement in any direction to discharge the gun.

SEA-GOING TURRET SHIPS.—"Engineering" (March 12, 1869) illustrates a new vessel of this class, designed by Admiral Paris for the French navy. It is a ship to carry two heavy guns, but it has only one turret, and is protected by armor only 5.9 in. thick on the vertical sides of the ship, 1.57 in. on the outside bridge, and 1.18 in. on the interior. The vessel is specially designed to carry sails, and would have three masts, by which the somewhat scanty power provided would be helped out. The following are the principal dimensions of the design:

Length of hull at water line		224.68 ft.
Outside width		50.84 ft.
Proportion of width to length		1 to 4.3
Width of ship inside		29.52 ft.
Proportion between interior and exterior width		1 to 1.72
Outside diameter of turrets		26.24 ft.
Calculated draught of water fore and aft		16.40 ft.
Volume of parallelopipedon		187,301 cub. ft.
Surface of the circumscribed rectangle at water line		11,416 sq. ft.
Surface of the circumscribed rectangle at midship section		827.80 sq. ft.
Di placement		110,214 cub. ft.
Weight of displacement		3075 tons.
Immersed midship section		713.8 sq. ft.
Area at water line		8600 sq. ft.
Proportion.	Of the volume of the hull to the parallelopipedon	0.588
	Of the flotation surface, to the circumscribed rectangle	0.754
	Of the midship section, to the circumscribed rectangle	0.857
Height from the water level to upper bridge		10.16 ft.
Height from main deck to sill of turret ports		2.62 ft.
Height of turrets		19.35 ft.
Thickness of plate of the armored zone,		5.9 in.
Height above water line		1.96 ft.
Depth below water line		4.92 ft.
Total		7.88 ft.
Proportion of armor above and below the water		1 to 2.5
Weight		356 tons.
Number of towers		1
Height of armor on ditto		7.28 ft.
Thickness of plate		.984 in.
Weight of armor		78 tons.
Total surface of towers		806 sq. ft.
Weight of lower belt (3.28 ft. high and 1.18 in. thick)		58 tons.
Weight of upper ring (984 in. thick),		97 tons.
Total weight of towers		155 tons.
Total weight of armor		776 tons.
Nominal horse-power		400
Number of guns		2
Total weight of armor per gun		388 tons.

Summary of Weights.

Armor	776 tons.
Engines	324 tons.
Guns	80 tons.
Masts, sails, etc	50 tons.
Stores, etc.	40 tons.
Water and tanks	20 tons.
Miscellaneous	8 tons.
Machinery for turning turret	24 tons.
Coal at the estimated draught of water,	279 tons.
	1601 tons.

THE MONITORS.—The following comments are made by a correspondent, upon the article compiled from "Engineering," in the first number, page 33 of "Van Nostrand's Magazine:"

The article begins with a numbered statement of the "advantages of turret ship." Respecting statement No. 1, instead of having "no masts," monitors, whenever necessary, do have masts. Case, "Monadnock." Her sail-power was sufficient to propel her five knots in a good breeze. There is no difficulty in applying sails to monitors. An official sail draught for one of our large monitors shows a spread of some 15,000 square feet of canvas, sufficient to propel the vessel nine or ten knots in a good breeze. The fact (in case of a monitor) of "having its guns and much of its armor further inboard," is by no means the reason why the monitor "rolls less than the broadside ship." The chief reasons are the position of the *metacenter*, as compared with the center of gravity of vessel, and of the displacement. Think of the immense area of water line section of monitors compared with their *length* and *displacement*. As to facts (observed) in relation to comparative rolling of our monitor and British broadsides in equal weather, the broadsides roll through an arc *three times* greater, hence from this point alone the depth of armor of a monitor below water—for equality of impregnability—*need be but one-third that of a broadside.* Putting masts on a monitor of the height and weight necessary for respectable sailing-power does not raise the center of gravity of the *mast* sufficiently to have a perceptible effect on rol ing.

2d. Respecting "Engineering's" estimate of "advantages of the broadside system," No. 1 says "they can carry masts!" *Per contra*, monitors have carried, and can carry them with safety. The statement that "a ship with a high freeboard will roll through an angle at which a ship with a low freeboard would capsize, from the weight of water on one side of deck," must have been made without proper calculation, or else on improper models. The pressure (and it is a heavy one) which would produce a heel of 18° on the Bellerophon would not produce a heel on a monitor of similar displacement of 7° ! This is no guesswork, but fact—the result of easily-made calculation.

Next respecting "artificial ventilation." This is, in fact, the only way, in a sea-going vessel, that decent ventilation can be had in bad weather, and in good weather, even with a low freeboard "open air exercise" at sea is possible. Think of the atmosphere in the cabin of the best of the English ships in bad weather when they are compelled to screw everything up tight! "Artificial ventilation" is one of the chief features in the "Stevens' battery," and a first-class feature it is, too. The atmosphere on the berth-deck of a frigate like the Roanoko was, in bad weather, with hoods on the hatches, only comparable to the Black Hole of Calcutta. Artificial ventilation, for sea-going purposes, is an American invention, and John Bull cannot cough it down any more than he could a 15 in. shot with 100 lbs. charge, and some 13,000,000 ft. lbs. of *vis viva*, which McAdamized his 8 in. solid slab, 18 in. backing and inner skin. What will he do against a 20 in., with some 22,000,000 ft. lbs.? High freeboard and 22 million ft. lbs. in shot scarcely make a good comparison.

3d. "The ship with a high freeboard carries its guns higher out of water." With either a central fixed tower (guns in casement), or a turret, the guns may, if necessary, be carried equally high. I have seen a plan of turret which carries its gun 10 ft. from the water, and that, too, without adding much weight. The celebrated Bellerophon only carries her gun $9\frac{1}{2}$ ft.

4th. "Engineering" further says: "Yet consider for a moment what a ship Ericsson designed to build —the Dictator—to carry two guns in a single 24 ft. turret, 9 ft. high and 15 in. thick * * * has a tonnage of 3,000 and a displacement of 5,000 tons * * * the boilers have far more grate area and heating surface than any vessel in the English navy." Now, the Dictator's displacement is inside of 4,500. The mistake of 500 tons is more than enough to make the turret $3\frac{1}{2}$ ft. thick, and allow for two 20-inch guns inside of it. As her side armor is $10\frac{1}{2}$ in. iron, 40 to 42 in. oak, besides inner skin, what broadside vessel of double her displacements yet built could whip her?

FILTER VANS AND CARTS FOR INDIA.—The scarcity of good drinking water is well known to be one of the most serious hardships of our army in India. It is notorious to every one of Indian experience that the soldiers are occasionally dependent on supplies literally poisonous and unfit for use, and the prevalence of cholera and other diseases has been distinctly proved to have been attributable to this cause. The authorities are now examining an important invention, manufactured by Messrs. E. H. Bayley & Co., the large wheelwrights of Newington Causeway, designed with great skill to meet this great want, and which seems admirably adapted to the purpose. It consists of a bullock van or cart on springs, containing a galvanised iron cistern, capable of holding about 250 gallons of water. The van is surmounted by a portable pump, by means of which the cistern may be filled from a pond, stream, or other source of supply. As the water when first pumped in may be very impure, the sediment is made by a simple arrangement to fall into a separate well or trap at the bottom of the van, whence it is drawn off by a cock. The water thus partially purified, next passes by a pipe into a second well, where it flows underneath two large filters, through which it is forced to percolate upwards. The value of this system of filtration by ascension is obvious, as the thicker impurities do not rise in the water, and consequently are drawn off by a cock without approaching the filters at all. Should the water be very impure, it can, by an ingenious contrivance, be made to pass, first through one filter, and then the other, and thus be doubly purified. After passing through the filters, the purified water flows into reservoirs, whence it can be drawn off into drinking cans from a row of brass taps at the back of the van. As fast as the water is pumped in at one end of the van, it is thus drawn off pure and filtered at the other. The cistern is thoroughly protected by an outer casing from the rays of the sun and kept cool.

These vans will be useful in our own camps, but will be a great boon to the army in some parts of India. We understand the patentees have received considerable orders from various foreign governments. While the House of Commons spends millions on guns and fortifications, it will assuredly not bogrudge the few thousands that will suffice for supplying every regiment in India with what will be invaluable for the health and lives of our countrymen.—*Army and Navy Gazette.*

EFFECT OF THE CHASSEPOT BULLET—ERRONEOUS REPORTS.—Dr. Gason, of Rome, reports as follows regarding the effect of different bullets at the engagement at Mentana, in November, 1867: The lightness of the Chassepot firelock and its loading at the breech caused a far greater proportion of wounds in the upper part of the body than was the case in those wounded by balls from the muzzle-loaders.—The entrance made by the Chassepot ball was very small; the exit not much larger. There was much less effusion of blood beneath the skin than in wounds by tho round ball or Miuié. The long bones were more frequently split. The immediate effects of the Chassepot were more fatal; but the ulterior effects less severe and fatal in wounds produced by the Chassepot than in these of the round ball or Minié. The external hemorrhage was greater in wounds produced by the Chassepot ball than by any other form of projectile; and in those places where the Italians fell when struck by it, there were large pools of blood.

Among the cases brought into the hospitals in Rome, there was not one where the wound produced by the Chassepot bullet bore any proportion to that mentioned in the report from the camp at Lyons—that "the exit was as large as a person's two fists." It would appear from the reports from the camp at Lyons, that in most instances the bodies of dead animals were used for the experiments.—*The Lancet.*

THE FRENCH NAVY.—The French fleet was composed on the 31st December, 1868, of 430 vessels, of which 331 were steamers with a total of 76,165 horse power. There are, besides, in course of completion afloat, 7 others of 3,710 horse power, and on the stocks 31 more of 12,405 horse power, and one sailing transport. This total is divided into two distinct portions, the first including the vessels which form part of the new fleet, to bo constituted in accordance with the programme in course of execution since 1857; and the second, composed of the remains of the old navy, considered unfit to take place in the new, either directly or after transformation. The new naval force, the only one that constitutes the real maritime strength of the empire, counts as completed 314 steamers and 10 sailing vessels. A table shows: (1) iron-clads to the number of 50 of various classes; (2) the unarmored fighting ships, 96 screw steamers; (3) 91 small steamers, despatch boats, tenders, &c.; (4) transports, 95 of various sizes; and finally, the two training schools, one for gunners and the other for naval pupils. Of the old fleet there still remain 17 steamers and 29 sailing ships.

ARMOR PLATES, made by coiling bars of iron as for Armstrong gun tubes, welding the coil by upsetting, cutting the coil in two, and flattening out the halves into plates, has proved a great failure, as the experts prophesied. The welds were found very defective.

THE NEW CHALMERS TARGET.—The recent death of Mr. James Chalmers lent a melancholy interest to the experiments which were lately carried out at Shoeburyness, with the last target designed by that gentleman. Although considerable hopes were entertained of the new target, they were not realized on the present occasion, the target having been pierced in every direction with the projectiles which were directed against it. Our readers are so well acquainted with the details of the Chalmers target, that it is unnecessary here to repeat them. It will be sufficient to state that the target lately experimented on was 15 ft. long, by 9 ft. high, the face being composed of two $4\frac{1}{2}$ in. armour plates of the same length as the target, and 4 ft. 6 in. deep. The target was 2 ft. $9\frac{1}{4}$ in. thick, including the angle iron ribs at the back. Mr. Chalmers had introduced eight modifications of backing, so that the target was divisible into as many different parts, each representing a modification of the general principle. A "Warrior" target had been made, and was placed beside it for enabling comparative results to be ascertained. The firing was from a 9-inch muzzle-loading rifled gun, with 250 lb. projectiles and 43 lb. powder charges, the range being 200 yards. As the trial, unfortunately, proved only the failure of the Chalmers target, it is unnecessary to follow closely the details of firing. Eight rounds in all were fired, five with solid shot and three with live shell. Rounds 1, 4, and 5 with solid shot were directed against the "Warrior" target, through which they failed to pass. Round 1 knocked a piece out of the edge of the target, and rounds 4 and 5 penetrated the target, but remained in it. Rounds 2 and 3 with solid shot were fired at the Chalmers target, through which they passed clean out to the rear. The first live shell struck the "Warrior" target, making a hole 2·23 inches deep, whilst the second and third shells passed through the Chalmers target, and burst in the rear. It was thus made apparent that the face plate of the latter target was much too weak for the work it was designed to do, and that in effect Mr. Chalmers had pushed his principle of elasticity too far. There is no question of the soundness of the principle, but the extreme lightness of the outer plate neutralized any effect obtainable from the backing. It is to be regretted that such a mistake in the designs of this target should have been made, and still more that the inventor is not here to profit by it, and to bring the labor of years to a successful issue.—*Mechanics' Magazine.*

THE HERCULES AT SEA.—Satisfactory reports have been received of the performances of the iron-clad Hercules on her voyage to Lisbon. Although dragging her large screw propeller, she several times exceeded a speed of ten knots under canvass, and performed the operation of "staying" with great ease. The whole consumption of coal upon the voyage was less than fifty tons, or one-twelfth of the quantity on board. She is also a very steady ship, rolling and pitching exceedingly little, not only under a press of canvass, but with a beam-sea running and little wind. The huge guns (each weighing 18 tons) were worked and fought every day with perfect success.

ENGLISH OAK—THE WOODEN WALLS OF ENGLAND.—The timber-built unarmed screw frigate Sutlej, is now having her machinery taken out at Portmouth, preparatory to being broken up. It was only in October, 1860, that the Sutlej made her first speed trial as a new ship over the measured mile, when she attained a mean rate of 13.076 knots. She was then considered one of the handsomest and swiftest ships afloat. She is now a striking illustration of the short life and costliness of a wooden-built ship of war.

A NEW NEEDLE GUN.—The Berlin correspondent of The London "Daily News," writes on Jan. 9: About a week ago the "Vossische Zeitung" astonished its readers with a paragraph announcing the invention of a new rifle, called the Zundwassergewehr, or ignition water gun. Although the experience of the last few years has prepared us for all sorts of wonders in the way of firearms, yet ignition water seemed an enigma which could only be solved by the man who knows how to set the Thames on fire. The passage was copied in other papers, and will probably excite no little interest in other parts of the world, until the prosaic explanation of a misprint has cleared up the difficulty. The real name of the invention in question is a "Zundmessergewehr," or an ignition knife gun. It appears that the cartridge is made of some peculiar kind of paper, and that it explodes when cut by a knife. This sounds very dangerous, but I must assume that a knowledge of the details would show that the ignition is not so simple as it seems. Lieut. Col. Count Lehndorf, one of the King's Adjutants, has tried the new rifle at the Hasenhaide range, near Berlin, in company of the inventor, Herr Meyhofer, a Prussian country gentleman, and the results were very satisfactory. Herr Meyhofer succeeded, in two experiments, in hitting the target 13 times in 36 seconds. Another wonderful invention is reported from St. Petersburg. A Russian officer has constructed a cannon which can fire 200 shots in a minute. It is extremely easy to handle, and very effective up to 1,800 yards.

A NEW GUNPOWDER.—A new composition of gunpowder is being tried in the French army and navy. The inventor, a M. Dessignolle, has substituted for sulphur the picrate or nitro-carbonate of potassa. The picric acid is a new compound, obtained from the mixture of phenic and nitric acids. The picric acid explodes by the heat, and there results nitrogen, carbonic acid, hydrogen, water, carbon and carbonate of potassa.

$$(C_{12}H_2K(A_2O_4)_3O_2 = 3Az + 5CO_2 + HO + H + 6C + KO\,CO_2)$$

The smoke produced is trifling, and the absence of sulphur makes it injurious neither to the men nor to the weapons. Besides that, when the powder is made only from picrate and nitrate of potash without carbon, a very violent powder is obtained, which is excellent for blasting. It has nearly the same strength as the nitro-glycerine, and seems to be less dangerous. The absence of smoke will be a notable improvement for tunnelling. It is probable that, when regularly manufactured, this new powder will be obtained at the same price as the ordinary gunpowder.

NOVEL GUN CARRIAGE.—A gun carriage and slide of a novel and very ingenious construction, by Messrs. Vavasseur, of the London Ordnance Works, for a 7-inch steel built-up rifled gun, was tested recently at Yarmouth, with the highest success. The compressor, which is the most important feature, consists of a cone and drum, working under a brakestrap, this friction gear being attached to the head of a long screw-shaft, actuated by a nut under the carriage, moving along it and turning it round. The great value of the system is that the compressor is always ready to be acted upon by the recoil, and is automatically put into gear the moment the gun carriage begins to move.

DEPTFORD DOCKYARD, which will be closed this year, is one of the most ancient dockyards in the kingdom—an old monastery, bearing date 1513, still stands in the yard, and is used as a storehouse. It was at Deptford Dockyard that Peter the Great learned the art of shipbuilding. The present strength in the yard is under 500 hands. The regular working strength is 841.

COST OF HEAVY GUNS.—The Ordnance Committee have discovered that the army Rodman 15-inch gun costs $6,500 each, for 49,000 lb. weight. The navy guns of the same caliber weighed 42,000 lb. The difference in weight, at 13 cents per pound, makes $910, which the navy paid more for their guns than was paid by the army. The navy contract with the Fort Pitt Foundry provided for the delivery of all guns on the seaboard at the expense of the maker, yet the Government paid for all this transportation. From the spring of 1864, all 15-inch guns procured at Pittsburg were taken without any powder proof, according to an order from the Chief of Ordnance. Therefore, guns procured since that time have been mounted in fortifications on expensive iron carriages, without being fired at all; and lately an order was issued from the Ordnance Department to subject them to a proof of charges of 100 lb. of powder, at the risk of the Government.—*Washington telegram to Philadelphia Inquirer.*

ORDNANCE AFFAIRS AT WOOLWICH ARSENAL.—Arrangements are being made for the construction of iron gun carriages for the navy at the Chatham Dockyard, though recently certain buildings in the Royal Carriage Department, Royal Arsenal, had been altered and fitted up with plant and machinery to carry on the works at a great cost. The removal of the naval carriages to Chatham will lead to part of the Carriage Department being closed. In the Royal Gun Factory Department, the Armstrong branch has been shut up for a considerable time with all its expensive machinery, in consequence of a large order being given for the conversion of guns from the smooth bore into rifled guns upon the Palliser principle, to be effected at the Elswick Factory, instead of at the Government establishment at Woolwich.—*Mechanics' Magazine.*

PALLISER'S PROJECTILES.—In a recent report of the Ordnance Select Committee are the following results of the penetrative power of shot and shell, fired from heavy rifled guns at a range of 70 yards. A Palliser shell weighing 398 lb., fired from a 10-in. muzzle-loader of 18 tons, with a charge of 54 lb. of powder, penetrated through 23 ft. of earthen parapet, and passing out in an upward direction continued its flight for 300 yards beyond. A 9-in. Palliser shot, weighing 248 lb., fired from a 9-in. 12 ton muzzle-loading gun with a 37 lb. charge, nearly passed through 23 ft. of earthwork, the point of the shot showing through the further side of the parapet.

KRUPP'S CANNON FOR PRUSSIA.—A large order for the 9-inch cannon which performed such extraordinary feats at Tegel has been given Mr. Krupp by the Prussian Government. The bill is expected to amount to 4,000,000 thalers, each barrel costing somewhere about 30,000 thalers. The same gun has just been adopted by the Belgian Government, to be placed on the walls of Antwerp. According to official intelligence received here, experiments made with the 9-inch cannon in Belgium resulted in the Bellerophon target being totally destroyed after eight rounds, the Warrior target having endured but seven.

AUSTRIAN IRON-CLAD.—The largest iron-clad in the Austrian navy—the largest ship probably ever launched in the Adriatic—has just been launched at Trieste. She is called the Lissa. The ship is built entirely of Austrian materials, and every detail of her machinery and armament will be Austrian. Her length is 272 ft.; breadth, 45 feet; displacement, 6,000 tons. Here engines are of 1,000-horse power, and her armament will be twelve 300-pounder Krupp guns.

NEW BOOKS.

A RUDIMENTARY TREATISE ON THE MANUFACTURE OF BRICKS AND TILES; CONTAINING AN OUTLINE OF THE PRINCIPLES OF BRICKMAKING. By EDWARD DOBSON, A. I. C. E., M. I. B. A. Revised and corrected by CHARLES TOMLINSON, F. R. S. Fourth edition. With additions by ROBERT MALLET, A. M., F. R. S., M. I. C. E., &c. With illustrations. London: Virtue & Co. New York: Virtue & Yorston. 1868.

The name of the author of this treatise is a sufficient guarantee that the contents will answer the expectations of the reader. If the "claims of long descent" are supposed to be of any importance to a building material, then bricks certainly take the foremost rank, and in all probability their future career will be as endurable as their past. It is true that the employment of stone, where works of great magnitude are concerned, becomes almost imperative, both for constructive reasons, as well as for the sake of æsthetical effect; but it will never supersede the more ancient material in structures of a smaller and less pretentious character. That there is an enormous amount of bad brickwork hourly erected in London and elsewhere, no one who is acquainted with the manner in which houses are run up by speculating builders will for a moment deny. At the same time, there are not wanting numerous examples of the same description of work which have withstood for centuries the attacks of the weather and the influence of time, and remain to the present day indisputable witnesses to the solidity and durability that is, or rather was, possible to obtain by that method of construction. But in those earlier times bricks were bricks and mortar was mortar. Mud and slime were unknown quantities.

As might be reasonably anticipated, it was not long after the introduction of machinery before its potent aid was called in to assist in the manufacture of bricks, and so far as their crushing strength is concerned, it appears that the machine-made brick will stand about one and a half times the weight that will crush the best hand-made specimens. In the manufacture of bricks, as well as in all artificial preparations, the success of the operation and the value of the product are chiefly dependent upon the selection of the material; consequently the selection and the preparation of the clay of which the bricks are composed demands not merely care and attention, but also experience on the part of the manufacturer. Next to this, the management of the kiln is an important detail in the process. From chapter I, which treats of the manufacture of bricks and tiles in Holland, and which is contributed by Hyde Clark, C. E., it seems upwards of a million bricks are sometimes burnt in a Dutch kiln. The Dutch have long been famous for their clinkers and other bricks of a hard description. Notwithstanding that the principle of brickmaking is everywhere identical, a great diversity exists in the various lesser operations connected with their production. The nature and extent of these vary with the district and locality where the manufacture is carried on, and the several methods practiced in the vicinity of the metropolis, in Nottingham, Staffordshire and other provinces, are fully described and investigated.

In addition to the regular established manufacture of these materials of construction at well known places, they are frequently made in large numbers in what might be termed an impromptu manner. Wherever any great excavation takes place, such as that for a large tunnel or dock, which requires to be "lined," the bricks for "lining" it are generally made upon the spot, provided that the earth be in any way suitable for the purpose. All that is wanted in a brick intended for tunnels, docks and other engineering works is, that it should be hard and sound, should ring well when struck, and not be too absorbent. Irregularity in shape and want of uniformity in color, however detrimental to house bricks, are of little or no consequence where strength and stability are the only featuros sought for in the building they compose. Chapter IX is devoted to a description of the different machines invented for facilitating brickmaking, and is well deserving the perusal of all interested in the subject. The illustrations are especially well executed, and are distributed with no sparing hand. In the appendix at the close of this valuable little volume there is a short chapter upon the science of brickmaking, in which the chemical nature of the operations, the composition of the various clays employed, and the effect of the combination of the several ingredients, are examined into. The publishers, in the production of the fourth edition of this well known treatise, have fully sustained in every point the acknowledged reputation of their firm, and also the value of the "Rudimentary Series."—*The Engineer.*

A TREATISE ON OPTICS, OR LIGHT AND SIGHT, THEORETICALLY AND PRACTICALLY TREATED, WITH THE APPLICATION TO FINE ART AND INDUSTRIAL PURSUITS. By E. NUGENT, C. E., Ex-principal of Commercial, Nautical and Engineering College, New York. London: Virtue & Co. New York: Virtue & Yorston.

This Treatise on Optics, by Mr. Nugent, is just one of those books calculated to demonstrate that the principles of this science, and, in fact, of any other, may be taught in a manner that can be readily comprehended, both by persons of limited information and of limited abilities. It must not be gathered from our statements that we recommend, or at all indorse, an unstudious or dilettante style of perusing a treatise on a scientific topic. * * * Starting with the definition of light, Mr. Nugent briefly refers to the various theories—ancient and modern—entertained upon that question, and it will be sufficient to remark that the wave or undulatory theory is now the usually received one among scientific men. It is true that the emissive theory still has its advocates, but it no longer meets with the universal acceptance it once did. The three chapters immediately following the first are devoted to an elucidation of dioptrics, or that branch of the science relating to the refraction of light. By the aid of several excellent diagrams the subject is fully and lucidly explained, including the formation of images by prisms and lenses. The one principal law of catoptrics, or that branch embracing the reflection of light, is that the angle of incidence is equal to the angle of reflection; and when this is understood, all the questions relating to the reflection of mirrors will be easily comprehended.

After perusing the chapter on caustic curves, which are practically and familiarly explained, we are introduced to physical optics, including the composition of light. This is one of the most interesting portions of the volume, and the various opinions put forward, and the experiments bearing upon the sevenfold or threefold composition of light, candidly and fairly investigated. Most of our readers are familiar with tho solar spectrum, which, according to Newton, consisted of seven, and to Sir David Brewster, of only three primary colors, red, yellow and blue. The latter philosopher accounts for the mistake into which he considers his scientific predecessor to have fallen, by attributing it to some imperfection in the manner of conducting his experiments. Be this as it may, the composition of white light may be regarded as consisting of the three colors only. A description of the eye, together with the laws of vision, and color-blindness, absorb chapter VIII. Under the head of "Optical Instruments" are explained most of those pleasing delusions, including the celebrated "Pepper's ghost." The details of the various descriptions of telescopes—the Newtonian, Gregorian, Gallilean and Herschellian—are illustrated by suitable diagrams, and a chapter upon the application of optics to the useful arts brings to a close this valuable addendum to our repertoire of books calculated to diffuse information and instruction among our artisans, and all who desire to become acquainted with the true principles of science. We may congratulate the publishers upon having produced a volume handy in size, neat in appearance both externally and internally, and admirably adapted for fulfilling the purpose which the author mentions in his preface was that which he had in view.—*The Engineer.*

SCIENTIFIC STUDIES; OR, PRACTICAL, IN CONTRAST WITH CHIMERICAL, PURSUITS: EXEMPLIFIED IN TWO POPULAR LECTURES. By HENRY DIRCKS, C. E., LL.D. Post 8vo. E. & F. N. Spon.

The first of these lectures is on the Life of the Marquis of Worcester; the second on Chimeras of Science. We have here an epitome of Mr. Dircks' larger memoir of the Marquis of Worcester, bringing together for the first time, in a popular form, what has never hitherto been accomplished; that is, a truthful notice of facts in connection with the life of the undoubted inventor of the steam-engine. Previously it had been the custom to supply every hiatus with some vague surmise or other, and, as each writer exercised his ingenuity as best he could, it became at length difficult to ascertain where the truth lay. Some declared he wrote his "Century" while confined in the Tower, others supposed he wrote it in France; Mr. Dircks shows that he wrote it after his release from imprisonment.

Mr. Dircks seems to be quite at home on the Chimeras of Science. He refers to various works on astrology, alchemy, and mathematical and mechanical chimeras, not omitting his own "Perpetuum Mobile; or, History of the Search for Self-Motive Power"—a work likely to be highly useful to young mechanics at their studies, and to older ones who have neglected them. Mr. Dircks concludes that—"Astrology is merely a philosophism, being empirical, wholly visionary, a mere fanciful system, compounded of incongruous mixtures of astronomical with human events, of mythology with theology, and of facts with pure fiction;" and that, while laying claim to the remotest antiquity, it makes no pretence to inspiration. Treating on alchemy, the author states that—"Alchemical writings are very numerous; they may be estimated at from 3,000 to 4,000 works, and an astonishing number of manuscripts." So insinuating was this delusion that Lord Bacon, Luther, Spinoza, Leibnitz, and many eminent moderns believed in finding the philosopher's stone, the gem of the Hermetic philosophy. Next follow the squaring the circle, duplication of the cube, trisection of an angle, and perpetuum mobile, illustrated by means of neatly engraved diagrams, to accompanying explanations. Among the squarers preference has been given to Mr. James Smith, of Liverpool, in plate 3. Arago declared that all that could be gained in computing "the area of the space included within a circle of thirty-eight millions of leagues radius may be determined within such a degree of precision that the probable error shall not exceed the space of a mite," or grain of sand, as others remark.

These lectures, notwithstanding their popular character, are replete with information, and cannot be read by the studious without satisfaction and benefit, as their author brings to bear on them a vast store of curious reading, and the result of years of practical experience.—*Mining Journal.*

COURS ÉLÉMENTAIRE DE PHYSIQUE. Par l'ABBÉ H. CABIAC. Paris.

THE LATHE AND ITS USES, OR INSTRUCTION IN THE ART OF TURNING WOOD AND METAL. (Anonymous.) 1 vol. 8vo. London: Trühner & Co., 1868.

A TREATISE ON LATHES AND TURNING. By W. H. NORTHCOTT. 1 vol. 8vo. Illustrated. London: Longmans, 1868.

There is no need to say much more of the second-named work than that it is a plainly written, unpretending and practical introduction to the use of the lathe, and instruction as to what may be done with it or by it, directly or indirectly. It deals not in the history or past phases of the turner's art, hut with the actualities of the present day; and is illustrated, among other plates, with some views of lathes, &c., produced from photographs furnished by some of the very hest makers, such as Fairhairn, Kennedy and Naylor, of Leeds, &c. This would be a good book to put into the hands of a lad commencing his apprenticeship in a tool-making or engineering shop. The first-named volume is still better—more exhaustive, and, we may say, a more scientifically written work, and hetter fitted for the advanced student of mechanical engineering. The author, who is prohahly an American, curiously enough thinks proper to conceal his name. He admits in his preface that a considerable proportion of his work consists in compilation from American journals; it may not he a hit the worse for this, however.

There are two appendices; one on the angles of tools, by Mr. Dodsworth Haydon, of Guilford; the other on a new arrangement of lathe and chuck to do rose engine work, by Elias Taylor, of Brighton. These, both hy English authors apparently, are well written, and the latter is useful to the ornamental turner.

As to fine-spun theoretic dicta for fixing the angles of tools for various sorts of work, we confess we have not much respect for them, notwithstanding the names of Willis and Bahbage, Holtzapffel, &c., with which such refinements have heen connected. All of practical value on the subject of these angles can he stated in a few senteuces, and hecomes insensibly learnt hy tact very soon by everybody. A razor, a wood knife, a wood chisel, a chipper for iron, a turning tool or drill, need different angles of edge; but we know so little of the nature of the resistance to division opposed hy solids, or of the arrangements of their constituent molecules, that theory really decides little or nothing worth knowing as to the *limits* of best angle for various materials and different conditions.

The fact is, a turning tool, for example, will cut nearly any metal in the lathe at many angles of edge between 60° and 90°, and by varying speed and other conditions of application of the tool, and holding the latter with mechanical firmness, the same results may be ohtained with larger variations of angle. For finisbing *soft* hrass the doctors fix the angle as 90°, *i. e.* a square scraping tool; but for turning *hard* steel or chilled cast iron the same, 90°, is not only the best hut the only angle that will stand long. Where is the *principle* that gets at these extremes? The fact is, much as has heen written—prattled, we are almost tempted to say—by theoretic amateurs on this suhject, the very fundamental hasis for any sound theory upon it remains to he discovered.—*Practical Mechanic's Journal.*

A PRACTICAL TREATISE ON MINE ENGINEERING. By G. C. GREENWELL, F. G. S. Second edition. London: Spon, 1869.

The first edition of this work was published fifteen years ago, and Messrs. Spon are doing good service in giving the world a second edition of a very valuable treatise, almost entirely rewritten, and puhlished in monthly parts. It is always difficult to judge of the merits of a book from a small instalment of the whole; hut Mr. Greenwell's reputation is one guarantee that the work will be good; the character of the first monthly part, now hefore us, is another, and Messrs. Spon's well-earned reputation is a third. The puhlishers supply a short prospectus, telling the world what the contents of the work are to be, viz: Geology, as applied to mining; classes of rocks commonly met with in mining for salt, coal and metallic ores; huilding materials; dykes, slips and mineral veins; internal heat; metallic ores and minerals associated therewith and with coal; smelting; boring and sinking tools; timbering; walling; tubhing; management of quicksands and clay; pumping engines and pumps; winding engines; ropes; pulleys; strength of timber; ropes and other materials; the working of mines; copper; lead; tin; iron; salt; coal; ventilation; theory and practice; fire damp; carbonic acid and other gases; explosions and other casualties, &c. The work will be illustrated with sixty-four large colored lithographs, four of which are contained in the first part. We must reserve a more extended notice of the work till it has made further progress towards completion. For the present it must suffice to say that Mr. Greenwell's information is accurate, and his style remarkahly easy, and even elegant, while the style in which the work is got up by the publishers leaves little to be desired. —*The Engineer.*

SYSTEM OF NAVAL DEFENCES. By JAMES B. EADS, C. E. Report to the Honorahle Gideon Welles, Secretary of the Navy. New York: D. Van Nostrand. 1868.

At the close of the American war, Mr. James B. Eads, an American engineer and shipbuilder, was commissioned to examine the naval constructions of Europe, and to report thereon to the Secretary of the United States Navy. The result of Mr. Eads' investigations were emhodied in this report. In this document, after touching generally upon the question of naval construction, and paying a well merited compliment to Mr. E. J. Reed, our Chief Constructor, in respect of the "Bellerophon," the author goes on to criticise the turret system. But the gist of the report is the puhlication of the author's designs for having from one to five fixed turrets within which the gun platform revolves. Mr. Eads of course falls foul of Captain Coles and Captain Ericsson, considering the deck joint a radical defect. On the whole, the "report" is not what we expected to find it, considering its title. It is true the author suhmits it as "the result of his observations ahroad," but having been commissioned "to examine the naval constructions of Europe," we should have expected something more than a little generalizing ahout European turret ships—which could be done hy the author in his own office—and a great deal of particularizing ahout his own scheme.—*Mechanic's Magazine.*

The "Army and Navy Gazette" gives a long *resumé* of Mr. Eads' arguments, and compliments him on his forcible style of statement, but expresses no opinion on the merits of the case.

BRITISH RAILWAYS — AS THEY ARE AND AS THEY MIGHT BE. By JOHN IMRAY, C. E. London: E. & F. N. Spon, 48 Charing Cross. 1869.

Various schemes for vastly increasing the number of passengers hy decreasing fares, and thus in the long run benefitting both the companies and the public, have been put forward. They are all too far advanced for our country and perhaps for our day. Mr. Imray's is less revolutionary than some that have heen proposed, and the following ahstract of it from the "Building News" will at least he entertaining:

The tickets for passengers to be issued hy Government, like postago or receipt stamps, to be sold at any stamp or post office, and available on any day and on any line. The tickets to be of two diffrent forms, and four colors—white for first class, red for second class, blue for third class, and yellow for luggage and parcels, these last to be adhesive. Square tickets to indicate a "short" journey, not exceeding twenty-five miles, and oblong tickets to indicate a "long" journey, over any distance greater than twenty-five miles. Every passenger while in a carriage to wear his tickets visibly attached by a hook or catch in his dress, so that the officers may see it. The prices of these tickets to be as follows:

	1st class.	*2d.*	*3d.*
Square tickets for short journeys..	1s.	6d.	3d.
Oblong tickets for long journeys...	16s.	8s.	4s.

Luggage tickets for any distance, 1s. each.

In cases where a line of railway belongs to two companies, and the first part traveled by a passenger does not extend twenty-five miles beyond a station where the passenger enters, the tickets to be collected and kept by the second company. In the case of long tickets the same system, but the second company to carry the passenger on to a distance of one hundred miles from the station where he started. Every railway company is to keep an account with a Government office — preferably a branch of the Inland Revenue Office — where the company is to obtain payment for its obliterated tickets, less a certain amount chargeable for duty.

CASSELL'S TECHNICAL MANUALS: ORTHOGRAPHIC AND ISOMETRICAL PROJECTION, DEVELOPMENT OF SURFACES, AND PENETRATION OF SOLIDS, &c. By ELLIS A. DAVIDSON, Lecturer on Science and Art in the City of London Middle Class Schools, and author of "Linear Drawing." Cassell, Petter & Galpin: London and New York.

A knowledge of orthographic projection is essential before the student can make working drawings of any bridge, house, roof or other example of construction, and this knowledge is only to be acquired by practically drawing the various diagrams and projections upon a tolerably large scale. * * *

This little volume commences with a description of the mathematical instruments ordinarily required by draughtsmen, and we heartily indorse the advice of the author, wherein he cautions his readers against bad and inferior instruments. It is always money well spent to buy the best tools, and no sensible person would ever think of doing otherwise. From the projection of single figures, the reader is gradually introduced to others of a more complicated nature, including the development of the cylinder and the helix. The last chapter treats on isometrical projection, a particular description of perspective delineation invented nearly fifty years ago by Professor Farish, of Cambridge. This is a very useful and at the same time a very characteristic style of drawing. It is admirably adapted for showing at a glance the *tout ensemble* of any architectural or engineering structure, the details of iron work or carpentry, and the general arrangement of details. At the same time it is not calculated to supply, strictly speaking, the place of working drawings. From the manner in which orthographic and isometric projectious are treated in the volume uuder notice, we consider it well calculated to form a valuable little text-book for the draughtsman and beginner.—*Building News.*

A DESCRIPTIVE TREATISE ON MATHEMATICAL DRAWING INSTRUMENTS, THEIR CONSTRUCTION, USES, QUALITIES, SELECTION, PRESERVATION, AND SUGGESTIONS FOR IMPROVEMENTS; WITH HINTS UPON DRAWING AND COLORING. By WM. FORD STANLEY. (Second edition.) Stanley: London.

This is a second edition of Mr. Stanley's treatise on mathematical instruments, to which several additions have been made. Amongst other things a description is added of a drawing board in the form of a tray for holding wood blocks while drawings are being made on them; and a new form of copying table, consisting of a sheet of glass, on which the drawing to be copied is placed, a mirror being arranged below the glass so as to throw the light up through the drawing. A description is also added of Amsler's planimeter, an instrument that deserves to be more generally known, and of a form of set square used on the continent for drawing section lines. This set square is provided with an arrangement such that by pressing a lever with the finger the square is shifted a certain distance. Altogether, Mr. Stanley's book contains much information that will render it useful to young draughtsmen.—*Engineering.*

AN ELEMENTARY COURSE OF PLANE GEOMETRY. By RICHARD WORMELL, M. A., Medallist in Mathematics and Natural Philosophy (London), author of "Arithmetic for Schools and Colleges." London: Thomas Murby, 32 Bouverie street, Fleet street, E. C.

In reviewing this book the "Building News" says the author of this volume has succeeded in investing a dry subject with a considerable amount of practical attraction, and illustrates each point by an appeal to the common sense of the student, in a manner that at once enlists his interest and arrests his attention. Lines and planes, angles, circles and triangles are described in detail, and the T-square, the level, plumb line, and square introduced, to show the application they have to the rudiments of other branches of education, and how they bear upon many points of technical and professional training. At the end of every chapter a number of questions for self-examination are added, sufficient to enable the learner to fix, by means of their solution, the substance of the chapter in his memory.

THE MANAGEMENT OF STEEL. By GEO. EDE; employed at the Royal Gun Factories' Department, Woolwich arsenal. From the fourth London edition. New York: D. Appleton & Co., 1867.

The successive editions of this little manual have gradually increased from a small pamphlet to a goodly duodecimo of over two hundred pages, and we aro glad to find that a reprint is accessible to our American workmen. As a practical worker in steel Mr. Ede stands very high, and his book affords evidence that he possesses the rarest of all faculties, viz: the ability to state plain facts in a plain manner. The result is that the book is crammed full of thoroughly practical directions and valuable suggestions.

Those who have carefully read the volume will, we think, agree with us when we say that, notwithstanding the unqualified praise which we have accorded to this book, it might be much improved if submitted to the editorial revision of some well-qualified person. In this way certain inelegancies, and consequently indefiniteness of expression, might be readily amended.—*Am. Journal of Mining.*

TREATISE ON VALVE-GEARS, WITH SPECIAL CONSIDERATION OF THE LINK-MOTIONS OF LOCOMOTIVE ENGINES. By DR. GUSTAV ZEUNER. Third edition, revised and enlarged. Translated from the German by MORITZ MULLER. London: E. & F. N. Spon.

Dr. Zeuner's treatise has been received on the continent as the standard work on valve-gear. The work is divided in all into ten chapters, devoted to the consideration of the simple valve-gear, and to the link-motions of Stephenson, Gooch, Allan, Heusinger von Waldegg, and Pius Fink, and the valve-gears of Gonzenbach, Meyer and Polonceau. There is also an appendix of the book, treating of the counter-effect of steam in engines fitted with reversing gear.

Dr. Zeuner's valve diagram was described and illustrated in the first number (page 20) of *Van Nostrand's Magazine.*

ENGINEERING FACTS AND FIGURES FOR 1868. London and Edinburgh: A. Fullarton & Co. 1869.

The sixth annual volume of "Engineering Facts and Figures" is now before us, and is no whit behind its predecessors. We need hardly state that the object of the work is to present a register of the progress in mechanical engineering and construction during each year. A leading feature in the present volume is a notice of the International Maritime Exhibition, held at Havre last year, and which was specially visited for the purposes of the work. Some additional notes are given on the Exhibition held in Paris in 1867, which tend to complete the subjects discussed in the previous volume. The matter is, as usual, arranged and classified under distinctive headings. The chief subjects considered are boilers, explosions, furnaces, fuel, steam engines, locomotives, marine engines and machinery in general, metals, railways and ships. Of course there is not room for everything in such a volume; but the selection of matter is admirably made, and the most important points of the various subjects are given, reference being made to the object from which the information is obtained, as a guide to the reader, should he desire further details. The volume is amply illustrated, and is got up in the usual neat style.—*Mechanic's Magazine.*

LOCOMOTIVE ENGINEERING AND THE MECHANISM OF RAILWAYS: A TREATISE ON THE PRINCIPLES AND CONSTRUCTION OF THE LOCOMOTIVE ENGINE, RAILWAY CARRIAGES AND RAILWAY PLANT. By ZERAH COLBURN, C. E. London and Glasgow: Wm. Collins' Sons & Co. New York: John Wiley, 535 Broadway. 1869.

One of the standing inquiries of students and experts in railway machinery has been, since 1865, "When will the remaining numbers of Colburn's Locomotive Engineering appear?" Nos. 13 and 14 are now before us. The subjects treated are The Link Motion, Combustion, Functions of the Locomotive Boiler and the Principles of the Blast. It is unnecessary to state that these subjects are ably treated. Mr. Colburn has been thoroughly fitted by his long experience as a practical locomotive engineer, and by his training as a student and writer on railway machinery, to handle these subjects in a manner at once thoroughly useful, sound and entertaining. Some of the chapters in these numbers were written by Mr. Ferdinand Kohn, whose work on the Iron and Steel Manufacture is noticed elsewhere. They were, of course, supervised by Mr. Colburn. We shall make further reference to this work as it proceeds.

ANNALES INDUSTRIELLES, PUBLIÉES PAR FREDUREAU, H. DE CHAVANNES ET CIE. A. CASSAGNES, Directeur. Paris, Rue le Peletier.

This is a new French bi-monthly engineering journal. So far this publication promises exceedingly well, and appears to be ably edited. It is, moreover, got up in very good style, each number being illustrated by carefully executed lithographic plates in addition to minor wood cuts interspersed in the text. The plates are of large size, and represent both civil and mechanical engineering subjects.

RAILWAY TRAVELING IN THE NINETEENTH CENTURY, WITH PLAN OF PROPOSED IMPROVEMENTS. By GEORGE LANSDOWN. London: Pettitt & Co., 23 Frith street, Soho. 1869.

This is a pamphlet advocating the American system of passenger cars for British lines.

LAXTON'S BUILDERS' PRICE BOOK FOR 1869, containing about 70,000 prices. London: Morgan & Chase, 1869.

TREATISE ON THE POWER OF WATER AS APPLIED TO DRIVE FLOUR MILLS, AND TO GIVE MOTION TO TURBINES AND OTHER HYDROSTATIC ENGINES. By JOSEPH GLYNN, F. R. S. Third Edition. Revised and Enlarged. New York: D. Van Nostrand. 1869.

It is a pleasure to see an old and valued friend, like this little work by Mr. Glynn, maintaining its well deserved popularity, and reaching a third edition besides an American reprint. The range of subjects treated in this volume is very wide, and almost all the data required in calculations relating to the flow of water; horizontal water wheels; turbines; undershot, overshot and breast wheels; water pressure engines and water rams, &c., are given very fully, and in such a shape that they can be readily used by the practical man. The publishers have certainly laid both students and practical men under deep obligations by this reprint.—*American Journal of Mining.*

THE TRANSACTIONS OF THE SOCIETY OF ENGINEERS FOR 1867. 1 vol. 8vo., with many plates. London: Spon, 1868.

This, the last volume of transactions of this thriving young society, quite maintains the character of its predecessors, and something more, as several of the papers are less of a mere elementary character—having just a little of the smack of schoolboy exercise about them, as was the case with a few of the former ones—and two or three are really able and exhaustive. This is especially true of Mr. Baldwin's paper on "Safety Valves," Mr. V. Pendred on "Tube Boilers," and, above all, Mr. S. W. Worssam on "Mechanical Saws." The volume, like all of the series, is got up in excellent style by the publisher; no clearer or better illustrations need be sought than the lithographs, which equal above a third of the volume in bulk.—*Practical Mechanic's Journal.*

IRON AND STEEL MANUFACTURE: A SERIES OF PAPERS ON THE MANUFACTURE AND PROPERTIES OF IRON AND STEEL; WITH REPORTS ON IRON AND STEEL IN THE PARIS EXHIBITION, ETC., AND DESCRIPTIONS OF MANY OF THE PRINCIPAL IRON AND STEEL WORKS IN GREAT BRITAIN AND ON THE CONTINENT. By FERDINAND KOHN, C. E. London: William Mackenzie, Paternoster-row.

This appears to us, upon cursory examination, to be one of the most complete and useful works extant upon modern iron and steel making. It brings the subject down to the present practice—however long that may last—and is very fully and well illustrated. It is favorably reviewed by the London "Mining Journal," and other professional periodicals. We shall give the work a more extended notice on another occasion. Meanwhile we advise mill managers and thorough students to procure it and review it themselves.

MURRAY'S TREATISE ON THE MARINE ENGINE. Fourth edition. London: Virtue & Co.

This is the treatise as to the publication of which the author, Mr. Murray, has so justly complained in the public papers. It was a good treatise for its time, probably, when first published, but needed much to bring up its leeway. This, the author complains, has been done or attempted by another hand, employed without his knowledge or sanction by the publishers, and whose work the author views as having by no means added to the value of his original. In that we are obliged to agree with the author. The book ought simply to have been reprinted as it stood, or all but rewritten, and not merely padded out by a bulky appendix, of which almost every page has been taken from easily accessible printed documents, &c.

RAILWAY NOTES.

Re-Rolling Old Railway Iron.*—The worn-out rails on the Erie and Pennsylvania Railways are re-rolled for further use in the same form, and this process is performed according to the following instructions, which are embodied in the specifications of that company:

1st. The old rails shall be piled in piles, and every piece shall be the whole length of the pile, and the pile so made shall be rolled into flats.

2d. All rails classed as 64 lb. to 67 lb. shall be rolled from a 9 in. rail pile, said pile to be made as follows:

3d. The said flats shall be put into a pile of proper size for a rail, each flat being of the full length of the pile, and of which flats the bar forming top or head of the rail shall be of a new, good, tough, granular re-worked iron, such as will weld well; to be $1\frac{1}{4}$ in. thick.

4th. The layers forming the central part or stem of the rail shall be of puddled or re-worked iron, of a good quality, or of old rails (at the option of the manufacturer), rolled to a thickness of not over $\frac{7}{8}$ in., and of such width that the various layers will break joints, and what is known as a staggered pile formed.

5th. The base of the pile, from which the bottom or flange of the rail is made, shall be of good, re-worked fibrous iron—the under layer of which shall be of full width and length of pile, not less than $1\frac{7}{8}$ in. thick. The pile shall be well and carefully heated, so as to insure a good weld.

6th. The short pieces furnished by the railway company, and all short pieces cut off by the rolling mill, shall be piled by themselves, and rolled into a flat, which flat shall either be piled in the rail pile or used in making flanges of the rail. The railway company shall have the right, from time to time, to direct in what part of said pile said flats, so made of the pieces shall be placed; not more than two such flats shall be in any one pile.

7th. The rails to be rolled to pattern furnished by railway company; to be 25 ft. long; not over ten per cent shall be of shorter lengths, but not less than 18 ft.; all rails to be undercut $\frac{1}{8}$ in.; to be notched $2\frac{1}{2}$ in. from each end, the notch to be $\frac{1}{2}$ in. deep and $\frac{7}{8}$ in. long, or of such dimensions as the railway superintendent may direct.

8th. It is mutually agreed that the railway company shall not exact from the iron works rails classed as re-rolled, to be of better material in the central parts and base of the pile than can be produced from the old iron furnished by said railway.

9th. Rails and process of manufacture shall be subject to inspection by such persons as the superintendent of the railway shall select and appoint for that purpose.

Mont Cenis Tunnel Completion.—According to Italian journals, the completion of the great tunnel is to be the occasion of a great International Exposition at Turin. The Government is to ask Parliament to vote the sum of 3,000,000 francs to cover the expenses of this enterprise. It is expected that the work will be finished in the winter of 1869-70, and that its use will begin early in the latter year. —*Annales du Génie Civil.*

* We copy this from an English paper, but we believe it first appeared in one of our own Journals; we have not the means at hand to give proper credit.

French Railways — New Company — Particulars of Works.—The larger part of the French railways are worked by five or six large companies; but recently many small local lines have been granted to new companies, who receive subsidies from the local authorities, and are free from many heavy regulations ordered by the Government to the great companies. A new company has thus contracted with the Conseil-général du Department de l'Hérault for 120 miles of new lines from Montpelier to the seaside, from Pezenas to Beziers, and from Montpelier to Lodeve. The company will receive a subsidy of £4,800 per mile. There will be only two classes of carriages, with the fares of the second and third classes of the main lines. The gauge will be the ordinary narrow gauge, the shortest radius of the curves will be 300 feet, and the inclines will not exceed one thirty-third. There will be no fences to the line nor guards to the level crossings, but the speed will not exceed fifteen miles an hour. The weight of the flat bottom rails will be forty-nine pounds per yard, and the average distance of the sleepers will be four feet. The rails are manufactured by the L'Horme Ironworks, near St. Etienne, at £9 15s. per ton. It is intended that the goods wagons of the main line should be admitted on these branches, but the engines will be special tank engines, with four coupled wheels, and weighing sixteen tons, or twelve tons empty. These engines will be supplied by Graffenstaden, near Strasbourg. There will be also some double bogie engines, which are manufactured by the Fives-Lille Company. The carriages, built at Lyons, will have a longitudinal intercommunication; there will be also some two-story carriages for the little line from Montpelier to the seaside, where a large passenger traffic is very probable. These lines will not have large works of engineering except a lattice girder bridge, with five spans of 120 feet each, over the Hérault river.—*The Engineer.*

Proposed Tunnel between Ireland and Scotland.—A scheme has been proposed for uniting Ireland and Scotland by a submarine tunnel. The entrance to the railway tunnel by which it is to be accomplished on the Irish side is to be from a point about midway between Cusheden and Cushendall, on the coast of Antrim, and on the Scotch side at Glenstrone, from whence it would run through the head of the Mull of Cantyre. The total length of the tunnel under water would be fourteen miles three furlongs, and it is said that the ground through which it would have to be made is exactly suited for tunneling operations, and the sandstone for lining it can be had in any quantity on the Irish side. It is proposed to construct the tunnel for a single line only, the extreme depth being twenty-one feet, and the clear width at the level of the rails fifteen feet. The estimated time that would be occupied in completing the tunnel is, allowing for all contingencies, under six years, and the cost under four and a quarter millions. To pay a dividend of five per cent, the weekly earnings must be forty-two pounds per mile, and an estimate is appended to show that the gross earnings would be largely in excess of this amount, and that the mineral resources of the land in the immediate vicinity of the Irish end of the tunnel would be immensely developed.

Punch's approved method of communication between passenger and guard—a shilling.

The Delhi Railway, when completed, will establish an unbroken line of railway communication between Calcutta and Lahore, a distance of 1,300 miles. The contract for its construction, for $302\frac{1}{2}$ miles, was let in 1864. The commencement of the work was, however, delayed until 1865. At the present time the wells for the foundations of the larger bridges have been sunk to the required depth. This railway, besides frequently crossing canals, spans three large and celebrated rivers, the Jumna, the Sutlej, and the Beeas, besides one great mountain stream, the Gugger. The aggregate water-way required for these rivers amounts to upwards of two miles.—On the southern section of the railway, between Umballa and Ghazeeabad, which was formally opened in November, there are eight large bridges, and ten for minor streams, comprising fifteen spans, varying from 60 to 102 ft. in length. On the northern section, seven important bridges are completed. Of materials, 90,000 tons, including permanent way, bridge work, fencing, and plant have been sent from England since the spring of 1865 for the formation of this railway. The date fixed by contract for the completion of the whole line is the third of May, 1870.

Safety of Workmen in Tunnels.—A new system, affording a great security to the platelayers in the tunnels, is used in the Blaisy tunnel of the Paris and Marseilles line. This tunnel, 13,600 feet long, is sometimes very smoky, and the men had great difficulty in being properly warned of an approaching train. An insulated wire has been laid by the side of the tunnel five feet over the ground. The ganger of the platelayers is supplied with a portable electric bell that he must suspend to the wire in the neighborhood of the place where his men and himself are working. The electric communication is completed by an iron wedge inserted between two rails of the line, and connected by a wire to the electric bell. As soon as a train goes into the tunnel, the signalman of the clock system at the entrance of the tunnel sends an electric current in the wire and rings the bell continually until the signal "line clear" is received from the other end of the tunnel.—*The Engineer.*

Altitudes.—The highest point on the Central Pacific Railroad is in the summit of the Sierra Nevada, it being 7,042 feet above the level of the sea, and the next highest is Pepoup Pass, 6,180 feet above the level of the ocean, and 541 miles east of Sacramento, in the Goose creek range of mountains. The highest points on the Union Pacific are Green river, 6,145 feet above the level of the sea; Benton, 6,635; Laramie, 7,175; Sherman, 8,424; and Cheyenne, 7,040.

Peat for Locomotive Fuel.—The following results have been obtained on the Grand Trunk railroad in Canada: Number of miles run by train, 683; aggregate distance run by all the cars, 15,267; average number of cars per train, 22.4; peat consumed, 48,745 pounds; wood for same work, 105,187 pounds; number of miles run per ton of peat, 31.6; number of miles run per cord of maple wood, 27.6; experiment in favor of peat, 14 per cent.

A Railway in Persia, from Teheran to a suburb 6 miles out, is in progress.

Railway Time Tables in Holland.—We find in the Dutch journal "Opmerker" the following lines:

"*Bois-le-Duc.*—The provincial Court of Appeals has just given its decision upon a writ of error, from the tribunal of Breda, in the case of M. J. Urban, residing at Brussels. The tribunal found M. Urban guilty of a violation of the law of Aug. 21st, 1859, containing provisions for the management of railways, in failing to cause the departure of the Rozendaal train at the time indicated in the tables on the evening of Sept. 29th. M. Urban was fined 200 florins, and sentenced besides to six days in jail.

"The Court of Appeals has confirmed the judgment, and the appellent has been compelled to pay the costs."

M. J. Urban, we believe, is the director-general of the Grand Central Railway of Belgium, which has a station at Rozendaal. It seems that the Dutch Government requires railway time tables to be kept up to. Nobody will blame it in this case. —*Annales du Génie Civil.*

Abandonment of Broad Gauge.—The northern section of the Great Western Railway of England is now worked entirely upon the narrow (4 ft. $8\frac{1}{2}$ in.) gauge. The 7 ft. gauge is being gradually abandoned on the entire line.

Railways in Persia—The Shah of Persia has recently granted to English capitalists the monopoly of railroad building in that county for twenty years.

A Car is now building in Jersey City, which will be the costliest, the largest and one of the most elegant in the world. It is for the Erie road, and will cost $60,000.

MISCELLANEOUS.

Notice to our Cotemporaries.—Several technical journals are in the habit of copying without credit from "Van Nostrand's Magazine" translations from French and German magazines. We do not quite see the propriety of copying without credit our abstracts of papers and articles from the English journals; but when we have undertaken the expense and trouble of translating as well as compiling, we think an acknowledgment thereof, on the part of our said cotemporaries, would be at once just and polite.

New Books.—It may perhaps be unnecessary to call the attention of our readers to the series of notices under this heading. This is probably the most comprehensive list of new professional books that is accessible to the general reader; and the notices present not only sufficient specifications of the subjects treated, but the average professional opinion as to the manner in which they are treated.

A New Alloy.—A new alloy, forming, we are told, a beautiful white metal, very hard, and capable of taking a brilliant polish, is obtained by melting together about 70 parts of copper, 20 of nickel, $5\frac{1}{2}$ of zinc, and $4\frac{1}{2}$ of cadmium. It is, therefore, a kind of German silver, in which part of the zinc is replaced by cadmium. This alloy has been recently made in Paris for the manufacture of spoons and forks, which resemble articles of silver.

Wooden Pavements in California.—Not content with giving a fair trial to the widely-known Nicholson wood pavement, the Californians have devised several kinds of their own, two of which, known respectively as the Perry and the Stow pavements, have been tested to some extent in the streets of San Francisco. The Perry method consists in having the blocks sawed in such shape that when laid down they will occupy a position in which the grain of the wood, instead of being vertical, will lie in an inclined position, with V-shaped grooves or recesses arranged between their upper portions, and filled with gravel unmixed with asphaltum, or other waterproof or binding substance, this last being considered unnecessary. The grooves or recesses are caused to break joints, and are, of course, designed to facilitate the foothold of horses, &c., passing over the pavement. It is claimed that by this plan of laying the blocks the latter are caused to mutually sustain each other, that their surfaces are less subject to being battered and abraded by iron-shod hoofs and the tyres of wagon wheels, and that the expansion of the blocks consequent on the absorption of moisture, instead of causing the pavement to "arch," will simply make each block slide slightly upon the inclined surface of its neighbor. The blocks employed in the experiments thus far made with this kind of pavement, have been subjected to a preservative process, in which the pores of the wood are filled with sulphates of lime and iron. The Stow pavement resembles the Nicholson in the shape and size of its blocks; but instead of the plank foundation of the latter has provided underneath it a bed of sand. The sand is densely packed to support the blocks, and also the superincumbent pressure of travel thereon, by means of longitudinal rows of wedges driven down into the sand alternately with the several series of block. The great advantage of this system lies in the facility with which it may be taken up and replaced when desired, as, for instance, in the case of sewage repairs, &c. Akin to the subject of pavements is that of sidewalks, and in the construction of these asphaltum appears to be coming into very extended use in the Golden State. In San Francisco they are made as follows: Upon the sand is laid a foundation of boards, upon this is placed a layer of brick, and upon the brick is spread a cement which is constituted by asphaltum from Santa Barbara, mixed with ordinary gravel of fine texture.—*Engineering.*

Specimens of Large Belts.—Messrs. Hoyt Brothers, of New York city, have lately finished two very large belts, a portion of an order for the American Print Works of Fall River, Mass. One is 228 feet long and 38 inches wide, double; the other 107 feet long by 36 inches wide, also double, each about five-eighths of an inch in thickness. Weight of the larger belt 1,998 lbs., and of the smaller one 810 lbs. One hundred and fifty of the choicest "buts" were selected from 3,000 hides, themselves sorted from about 9,000. The leather of these belts is wholly from domestic cattle, and tanned with oak bark only, at the tannery of the company in Cumberland, Md., no extraneous acids or hot liquors being used. At first price the value of the largest belt would amount to over $2,800. The material and workmanship are certainly creditable to the manufacturers.—*Scientific American.*

The experiment of making belting from paper has proved a success in the hands of Crane & Co., at Dalton, Massachusetts, and the article is now used in all their own mills and several other manufacturing establishments. The belting resembles the genuine oak-tanned leather, and serves alike well in a dry or damp atmosphere.—*Engineer.*

The Late Ocean Steamship Race.—The City of Paris (Inman line) steamed from New York to Queenstown in 9 days 7 hours 23 minutes; stopped at Queenstown 20 minutes; steamed from Queenstown to Liverpool in 18 hours 27 minutes; total run, 10 days 2 hours 10 minutes.

The Russia (Cunard line) steamed from New York to Queenstown in 9 days 8 hours 5 minutes; stopped at Queenstown 23 minutes; steamed from Queenstown to Liverpool in 17 hours 12 minutes; total run, 10 days 1 hour 40 minutes.

The City of Paris won the race to Queenstown, beating the Russia by 42 minutes only. The Russia won from Queenstown to Liverpool, beating the City of Paris by 75 minutes, to which add 3 minutes longer stoppage at Queenstown; the Russia recovering her lost way, and winning by 33 minutes on the total distance steamed, which by the Russia's log was 3,066 miles in 10 days 1 hour 17 minutes, or about $12\frac{2}{3}$ miles per hour whilst under way in steaming.—*Cor. Engineer.*

A New Submarine Light.—An interesting experiment was recently made at the residence of Dr. Doremus, in New York city, in order to test the utility of a new method of illumination under water, invented by a lady—Mrs. Devoe—and designed to facilitate the various operations of submarine engineering. The plan, which has been patented by the inventor, or rather the "inventress," is simply this: Two rows of convex glasses are arranged in the side of a vessel below the water-line, and suitable lights—magnesium, calcium, or electric—are so arranged in relation with the glasses and with appropriate reflectors that the rays are thrown out into the water to illuminate the same. It is intende to use in conjunction with this apparatus a peculiarly constructed device by which objects in the water will be reflected upon a submerged mirror in such a way that the images may be perceived on looking down the tube or body of the instrument, which resembles that of an ordinary telescope.—*American Artisan.*

Preventive for "Dry Rot."—Builders, allotment gardeners, and others who employ home grown timber for fencing and other purposes, will be glad to hear that an effectual preventive for the "dry rot" has been discovered. The recipe is forwarded to the "Gardeners' Chronicle" by Mr. J. Baily Denton, and has been thoroughly tested by experiment. It consists in soaking the timber for a short time in lime-water. A pit or tank, or good-sized barrel, according to the extent of requirement, will answer the purpose, the lime being added to the water in the proportion of eighty-eight grains to one gallon. Timber creosoted in this way stands the weather remarkably well, and is not subject to the decay to which unprepared timber is so liable.

A New Light.—Mr. James Allison Hogg, gas engineer, Edinburgh, has discovered a method of producing intense light with coal gas by mixing it with atmospheric air. The mixture of gases is lighted after passing through a tissue of iridio-platina wire at a determined pressure. In a few seconds the metal becomes heated up to a white heat, the flame disappears, and an intense white light is the result. An enlarged picture has been taken by its aid on prepared photographic paper. The light will burn in a gale of wind without any protection round it, and a downpour of rain will not affect it.

Preserving Timber.—Dr. L. Feuchtwaner's process for the preservation of timber is simply to steam the timber, and then inject a solution of silicate of soda for eight hours, after which the wood is soaked for the same period in lime-water.—*Engineer.*

VAN NOSTRAND'S
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PERMANENT WAY.

REPORT OF THE STATE ENGINEER OF NEW YORK, PREPARED BY S. H. SWEET, DEPUTY.

From the advance sheets of the Report of the State Engineer and Surveyor of New York, on Railroads.

[Continued from page 388.]

STEEL RAILS—THE RESULTS.—Bessemer steel rails have been in regular and extensive use abroad, over ten years. For some five years large trial lots have been laid on various American roads having heavy traffic, and during the last two years importations have largely increased.

The manufacture of steel rails has also been commenced at four large establishments in this country, and some 7,000 tons of home manufacture have been produced and laid down. It is estimated that from 40,000 to 50,000 tons of steel rails are in use on our various railways. Among the users of steel rails are the Hudson River, Erie, and Pennsylvania railways — 10,000 tons or more each; the Lehigh and Susquehannah (entirely built of steel); also the Philadelphia & Baltimore; Camden & Amboy line; Lehigh Valley; New York Central; New York & New Haven; Naugatuck; Morris & Essex; Cumberland Valley; South Carolina; Chicago & Northwestern; Chicago & Rock Island; Chicago & Alton; Michigan Southern; Michigan Central; Lake Shore line; Chicago, Burlington & Quincy; Pittsburg, Fort Wayne & Chicago; also the Boston & Providence, Boston & Worcester, Boston & Maine, Boston & Albany, Eastern, Connecticut River and other lines in New England.

THE WEAR OF STEEL RAILS.—As no steel rails are reported to have worn out on our roads, the comparative durability of steel and iron cannot be absolutely determined.

The president of the Philadelphia & Baltimore railway states (in the letter before quoted) that the use of steel commenced in 1864, that the rails (25 miles in all) were laid on the most trying parts of the line; that none have been taken up on account of breakage, wear or defect; that upon the portion of the line near Philadelphia, the first steel rail imported had already worn out sixteen iron rails; and that none of the steel rails have shown any imperfection, but are all wearing smoothly and truly.

On the Pennsylvania railroad, the report of the Chief Engineer for 1868 states that 11,494 tons of steel rails had been purchased, and 9,956 tons laid. The first were laid in 1864. They are all wearing smoothly, showing no change except the slight diminution of section to be reasonably expected from the heavy traffic. No steel rails have yet worn out. The report of the Superintendent (Feb., 1869), says: "The use of steel rails continues, with satisfactory results, and 4,544 tons of this material have been laid since date of last report."

It is officially reported that on the Camden & Amboy line, some of the steel rails laid three years ago are now good in places where iron lasted but a few months.

The last report of the Engineer of the Lehigh Valley railway says: "Another year's wear has made no perceptible impression upon the 200 tons (of steel rails), the first of which was laid in May, 1864, none of which have broken or given out since last report. These rails have had a severe test, being in those places in the track where they are subject to the greatest wear, and being laid with a chair which is much inferior to the most approved joint now in use. There is no longer any possible doubt as to the superiority of steel over iron in economy, as in every other respect."

Unofficial reports from the Erie, Hudson River and other roads show that the above statements represent the average quality of steel rails.

The last report of the New York & New Haven railway states that "the subject of steel rails has received special attention, and after a careful investigation of all the points involved, it has been determined hereafter to make all renewals of track with steel rails only; 2,600 tons of Bessemer steel rails have been contracted for on account of renewals for the present year."

The report of the Morris & Essex railway for 1868 says: "During the last year one track through the tunnel has been relaid with steel"—also some 150 tons of steel laid elsewhere. "The wear of steel shows conclusively that economy will require its use on all heavy grades and sharp curves."

The last report of the New Jersey Railroad and Transportation Company says: "It is probable that steel rails will be gradually laid the entire length of the road, the greater durability of these rails, overcoming the objection to their increased cost.

Within the last three years, two notable papers have been read before the Institution of Civil Engineers, in London, upon the maintenance of way and the wear of rails—the papers of Mr. Price Williams and Mr. C. P. Sandberg. They were followed by prolonged discussions, in which the makers of iron rails took a conspicuous part, lecturing the engineers on professional subjects. The general facts and conclusions elicited have been published in the various engineering periodicals, and are extremely favorable to steel for lines of heavy traffic. A great number of instances of the comparative wear of steel were cited. In one case 23 iron rails had been worn out, where a steel rail, laid end to end with the iron, was not yet worn down. In other cases the wear was 17 to 1. It is conceded that any steel rail will outlast 6 iron rails. In fact, the remarkable wearing qualities of steel rails have never been doubted or questioned.

Breakage of Steel Rails.—Some steel rails of English, French and American manufacture have broken in service. In several cases the cause has been ascertained by the direct analysis of the broken rail. The cause was phosphorus. In some other cases, where analyses were not made, the general character of the iron used has been ascertained, and the trouble has been inferred to be phosphorus, or, in some cases, an excess of silicon. It is well known to steel makers that a very minute proportion of phosphorous (above .02 per cent) will make Bessemer steel brittle. In other cases, rails have broken at the mark of the "gag" or instrument for straightening the rail cold. The rails had not been properly hot straightened, or were finished at too low a heat. More rails have broken through punched fish-bolt holes and at punched nicks in the flange, than at any other places. Experiments prove that punching a hole in a steel rail sufficiently hard to wear well, weakens it. Three or four rails are reported to have broken, or rather crumbled, by reason of large flaws. Upon examination it was found in one case, that a steel rail end had been placed in the ingot mold, and that the liquid steel poured around it had not perfectly united to it. This practice in casting was therefore abandoned. In another case, a lump of clay appeared to have fallen into the mold and to have become cast into the ingot. In another case, too much of the fag end of the ingot had been left upon the rail—in other words, the rail had been sent out in an unfinished state. These causes of failure will be again referred to.

The *total* breakage of steel rails, in this country, and the comparative breakage of steel and iron have not been reported. The total breakage of steel on several roads has been officially reported.

Upon Jan. 1st, 1869, on the Hudson River railway, out of eleven thousand tons of steel rails in use, some of which had been laid three years, eleven rails had broken. The greater number of these rails were in use during the excessively cold winter 1867–8, when it was unofficially reported* that 113 iron rails broke in one day on this railway, and when it was officially stated that 1,000 iron rails broke in a month on the Erie railway.

On the Erie railway, out of 8,000 tons of steel rails in use Jan. 1, ten rails had broken. Some 800 tons of these rails were of American manufacture, and none of them have broken.

* "Engineering," March 27, 1868.

Upon the main line from New York to Philadelphia, a small quantity of steel rails were laid four years ago, and 200 tons of very slender steel rails, two years ago. The rest of the steel on this line was laid in 1868. Out of the entire 1,500 tons in use, one rail has broken.

Upon the Philadelphia, Wilmington and Baltimore railway, the President, Mr. Hinckley, states (in a letter before quoted) that out of 25 miles (say 2,400 tons) of steel rails "we have never broken one in use, nor taken up one on account of wear or defect."

The Chief Engineer of the Pennsylvania railroad reports that "some lots of American steel received have been found too hard and brittle, having a tendency to break easily; these have been carefully excluded from main tracks. The recent American steel rails furnished have been found fully equal in toughness and wear to the best foreign steel, having been subjected to severe tests under a falling weight."

On the other hand, a bad lot of steel rails have been removed from the track of the Reading railway, and the breaking of some steel rails on the Michigan Central railway is reported, although the use of steel is continued on that line. Mr. James F. Joy, President of the Chicago, Burlington and Quincy railway and of the Michigan Central railway, reports as follows, as to the use of steel rails (3 miles) on the former road: "The result has thus far not been such as to encourage the Board in an extended use of it in the ordinary track of the road." As to the results of 3 miles of steel on the Michigan Central, Mr. Joy says: "The steel rail thus far has hardly borne the test, having been found more liable to break than iron. As the average life of iron on the road is about 8 years, it is somewhat more than questionable if it will be found economical to substitute steel for iron in the track of the road. At stations and where the life of the iron is short from great wear, it is expedient, perhaps, to make the substitution."

It is a rather remarkable fact, however, that the Superintendent, Mr. H. E. Sargent, in the same report of the Michigan Central, says: "Three hundred tons of English steel rail, manufactured by John Brown & Co., after the Bessemer process, were laid early last year in some places where exposed to severe service. They have worked well thus far, hardly showing perceptible wear at any point."

In the absence of further official information, it is fair to assume that the breakage of steel rails is only a small percentage of the breakage of iron rails. Indeed, the latter is of daily occurrence, and is rarely considered by the public, except when lives are lost, and not always by railway managers when they make contracts.

Tests and Improvements.—The very important question now arises—Can steel rails be relied upon to give the satisfactory results above quoted, or improved results—can the evil of breaking be practically overcome?

We have seen that the chief and usual cause of brittleness is phosphorus. It is well known that the great deposits of iron ore in this country, such as the Iron Mountain and Lake Superior are practically free from this impurity. The quality of the ores in this and adjacent States is various. Those of the Housatonic valley are generally well adapted to steel making; the magnetic deposits of Lake Champlain are generally unsuitable. The cheap charcoal irons of Alabama, Virginia and Tennessee are generally very pure. The Cumberland irons of England, made especially for Bessemer steel, and used by Brown, Cammell and other first-class makers there, have also been imported to our steel works at reasonable rates. But however plentiful the ores suitable for steel may be in this country, great care in smelting and in the selection of fluxes will be indispensable to a uniform product. The manufacture of pig iron in this country has been so remunerative, that iron-masters have not heretofore felt impelled to introduce the refinements that characterize the smelting process abroad. A uniformly bad iron would, of course, be avoided by the steel-makers—the danger lies in the creeping in of impurities, by reason of improper manufacture, when the *general character of the iron is good.* This cause of failure may obviously be avoided.

Upon the introduction of the new manufacture in this country, our steel-makers appear to have made the natural but inexcusable mistake of neglecting analyses, critical inspections and rigid tests. This error was copied from the early English practice. In both cases it led to uncertain results, and injured the reputation of the product. Now it is reported by our steel-makers that they buy no irons until after they are specially analyzed; that they mix a large number of irons for each charge of steel, so that any accidental impurities in one may be largely diluted; that they test all charges of steel by welding, cold bending and otherwise; and that they test rail ends from each charge of steel made. One steel axle maker advertises that he makes *each* axle four feet longer than required, and tests it by dropping a 1,640 lb. weight 5 times upon this end from an height of 20 feet.

The punching of steel rails has been abandoned. Several kinds of power and hand drilling machines have been introduced, that do the work rapidly and well. The loss from the neutral axis of a rail, of the little material necessary to let a bolt through, cannot sensibly weaken it. To prevent the rails from creeping, the engineer of the Pennsylvania railway pins them to several sleepers by means of $\frac{1}{4}$ inch holes drilled in the flange. There are also other and better devices for preventing end movement, which do not weaken the rail at all.

The grand advantage of steel, for service under concussion and wear, is its homogeneity. Having been cast from a liquid state, it is sound and uniform, and free from the laminations and layers of cinder and numerous welds which characterize wrought iron, especially the low grades of wrought iron usually put into rails.

The tests above referred to would appear to amount to a guarantee against rails breaking in the track. The causes of failure mentioned, are obviously not a necessary feature of the Bessemer process, nor is uncertainty regarding the quality of the product an inherent difficulty. Perhaps no metallurgical process is more simple and less liable to variable features and results, *provided always* that the iron and the other materials and the machinery employed are of good quality Mistakes in the process of manufacture are of very rare occurrence, because it is less trouble to go right than to go wrong, and because the manufacture is in a very small degree dependent on the skill and judgment of the workmen. Melted cast iron is weighed into the converter, a steady blast is applied to it until the flame suddenly and unmistakably drops and changes color, indicating the complete removal of the carbon, and then a quantity of recarburizing material is added by weight. There is no guess work at any stage of the process, and the absolute determinations of the spectroscope may, if required, be employed as to the period of decarburization. Bad, refractory materials, impure coal, weak and fluctuating blast, and careless management of the casting, contribute to produce defective steel; but the chief uncertainty, in this country, has been in the pig iron. The experience of the Pennsylvania railway, before quoted, proves, however, that this difficulty has been avoided. And the results at the Cumberland furnaces, in England, are remarkable proofs that *uniformity* and excellence of quality are a simple question of blast furnace construction and management, when the coal and ores are reasonably pure. Notwithstanding the searching character of the tests referred to, the trial bar and the trial rail-end from each charge, it has been considered desirable to establish a still more certain and comprehensive system of tests, and to improve the manufacture by ascertaining the effects of different processes and treatment upon the ingots. To this end, preparations have been commenced at one of the steel works in this country, to determine, at whatever expense of time and money may be necessary—

1st. What reasonably rapid and convenient test of steel rails and axles will represent in kind (though, of course, exaggerating in degree) the test of actual service, The heavy weight falling upon the rail is objected to on various grounds. It does not prove that the rail will stand *numerous* blows accompanied by flexure, and it may prove that the rail is too soft to wear well.

2d. The exact effect of temperature upon the strength of steel of various grades.

3d. The effect of annealing upon the strength and durability of steel rails.

4th. The effect, as to strength and durability, of drawing down rails from ingots of large size, as compared with drawing them down from ingots of small size—the exact value of reduction.

5th. The comparative effect, as to strength and durability, of drawing the ingots, at the first stage, under the hammer or in the rolls. However valuable the effect of hammering may be upon wrought iron—squeezing out the cinder and perfecting the weld *in detail*—the conditions of steel are totally different. Steel has no cinder, and is already homogeneous, requiring no welds. It is, therefore, probable, that while hammering might make the mass a little more dense and hard, rolling would produce the more uniform structure and the more soft and ductile product.

6th. The uniformity of ingots from the same charge of steel. It is obvious that all parts of a ladle full of liquid steel, having been boiled together and thoroughly mixed, should be alike mechanically. Any chemical differences would be impossible at so high a temperature—some 5,000 deg. Fahr. Some experiments were recently made for the Central Railway of Orleans, to test this and other features of Bessemer steel.* The result showed the practical identity, not only of two ingots chosen at random from the same charge, but of the various charges under experiment.

Improved Traction upon Steel Rails.—It has been too much the practice of railway managers to consider only the increased durability of steel. A less striking, but perhaps equally important advantage, is that it has double the strength and more than double the stiffness of iron. Some three years since, Mr. George Berkley made, in England, above 600 tests of the stiffness of steel and iron rails of equal section. The rails were supported on 5 ft. bearings, and loaded with dead pressure at the middle. The first rails tried weighed 68 lb. per yard, and loads respectively of 20 tons and 30 tons were applied. The average of 427 tests of the Ebbw Vale Co.'s and two other standard makers of iron rails, gave, with 20 tons, a deflection of $\frac{5}{8}$ in. and a permanent set of $\frac{1}{2}$ in. With 30 tons the deflection was $2\frac{1}{5}$ in. and the permanent set $2\frac{1}{16}$ in. With Brown's steel rails, 45 tests gave an average deflection of but $\frac{5}{16}$ in. and a permanent set of $\frac{1}{8}$ in. With heavier rails and loads, the comparative stiffness of steel was still more marked. The great and constant resistance to traction, and the wear and tear of track, wheels and running gear, due to the deflection of rails between the sleepers, and the perpetual series of resulting concussions may be much reduced, or practically avoided, by the use of rails of twice the ordinary stiffness; in such a case, however, reasonably good ballasting and sleepers would be essential. When a whole series of sleepers sinks bodily into the mud, the consideration of deflection between the sleepers is a premature refinement. If the weight of steel rails is decreased in proportion to their strength, these advantages of cheaper traction and maintenance will not, of course, be realized. The best practice, here and abroad, is to use the same weight for steel as had been formerly employed for iron.

Steel-Headed Rails.—Many attempts have been made in England, on the Continent, and in this country, to produce a good steel-headed rail, and not without success. Puddled steel heads have all the structural defects of wrought iron, as they are not formed from a cast, and hence homogeneous mass, but are made by the wrought iron process, and are, in fact, a "high" steely wrought iron. They are, however, a great improvement upon ordinary iron, although probably little cheaper than cast steel heads. Rolling a plain cast steel slab upon an iron pile has not proved successful. The weld cannot be perfected, on so large a scale, and the steel peels off under the action of car wheels. Forming the steel slab with grooves, into which the iron would dovetail when the pile was rolled into a rail, has been quite successful. The greater part of some 500 tons of such rails, made in this country, and put down where they would be severely tested, about 4 years ago, have outworn some 3 iron rails. Others failed in the iron stem, which was too light, after a shorter service. Rolling small bars of steel into the head of an iron pile has been recently commenced at various mills in this country and in England. No conclusions are yet warranted by the short trial of these rails.

There is a growing feeling among engineers and steel-makers, that the compound rail, made wholly or partly of steel, will prove more safe and economical than any solid rail, and that the defects of the old compound iron rail, largely used in this State some years since, may be avoided, since these defects were chiefly due to the nature of the material. The experiments in this direction will be watched with great interest by railway managers, for if the same durability of track can be obtained with a steel cap as with an all steel rail, the first cost will be greatly decreased. A rail made in two or three continuous parts, breaking joints, is also a practical insurance against disaster from broken rails.

* See Van Nostrand's Magazine, Vol. I, page 104, for complete account of these experiments.

THE SIEMENS-MARTIN PROCESS.

We print below the particulars of a charge of Siemens-Martin steel, produced at the works of Messrs. Cooper, Hewitt & Co., at Trenton, under the superintendence of Mr. F. J. Slade, who introduced the process in this country. We are informed that the time of the process is often shorter, and the yield greater, but that this is a fair sample. Certainly not an unduly favorable one.

We have experimented with a bar of steel made by this process, exactly as represented in the following table, and have found it to be very soft and tough, and capable of sustaining a very high heat:

Martin Steel Process, April 21, 1869, 6.25 A. M. to 6.22 P. M.

CHARGE, 78: INGOTS, 543–560. CLASS I.

Time of charging.	West Cumberland Pig.	Franklinite Pig.	"A" Iron Re-carb.	Steel Scrap.	West Cumberland Flats Puddled.	Time of Taking Proofs.	Remarks.
6.25	1,000	500	...	...	{ 2 Ingt	4.20	Strong cold with fine fracture.
7.53	...	...	...	495		5.05	Red short at orange, tough cold with good granular fracture.
8.20	...	...	...	307	...	...	
9.06	...	...	...	400	...	6.00	Hammered well, strong cold with fine fracture.
9.42	...	...	...	400	...	...	
10.50	...	...	...	400	...	...	
11.23	...	...	...	...	400	...	
11.50	...	...	...	...	400	...	
12.32	...	...	...	...	400	...	
1.40	...	...	...	...	400	...	
3.28	...	...	...	...	400	...	
4.29	...	...	...	...	400	...	
5.24	...	...	100	...	...	...	
6.22	poured.		...	...	...	...	
Total.	1,000	500	100	2,002	2,400	...	

DR.

To Pig Iron	1,600
Steel Scrap	1,507
Puddled Iron	2,400
Ingots	495
	6,002

CR.

By Product:	
By Ingots (cast in groups)	5,124
Scrap	339
Waste, 8.9 per cent	539
	6,002

Coal for Producers, from 7 A. M., April 21st, to 7 A. M., April 22d, soft, 6,864: duration of Charge, 11 h. 57 m.

METHOD OF ELECTRO-PLATING CAST IRON, BY PROF. DR. BÖTTGER.—One ounce of nitrate of silver is dissolved in 16 ounces of distilled water when boiling, and two ounces of cyanide of potassium are added. When these substances are completely dissolved, the fluid is mixed with a solution of one ounce of chloride of sodium in 48 ounces of water. The cast iron object to be plated must be free from oxide, and has to be cleansed by dipping it a few minutes into nitric acid of a specific gravity of 1.2, immediately before being plated. The plating is done in the above described solution, with the assistance of two or three galvanic elements of moderate strength.—*Polyt. Notizblatt.*

OUR TECHNICAL SCHOOLS.

THEIR DEVELOPMENT RATHER THAN THEIR INCREASE.

New England, which, though composed of six states, is, in many important respects a unit, has her *Chandler Scientific School* connected with Dartmouth College, N. H., and recently presented with forty thousand dollars, expressly to develop its course in civil engineering; her *Massachusetts Institute of Technology* at Boston, with an endowment—expended and appropriated—approaching, if not amounting to a million of dollars; her *Worcester School of Industrial Science*, with a total endowment approaching three hundred thousand dollars, and a well equipped machine shop, analogous, for the study of mechanical engineering, to a laboratory for the study of chemistry; her *Agricultural College* at Amherst, with an endowment of a third of a million dollars, and begging the State of Massachusetts for one hundred and fifty thousand more; her *Sheffield Scientific School* at New Haven, with an endowment recently stated at "only three hundred and twenty-seven thousand dollars," and her *Lawrence Scientific School* at Cambridge, Mass., also well endowed.

New York is probably not very far from equal to all New England, in extent, population and wealth, and she, accordingly, presents her quota so to speak of five schools of science. There are the *Rensselaer Polytechnic Institute* at Troy; the *Engineering Department at Union College*, Schenectady, the *Cooper Institute*, and the *School of Mines of Columbia College*, both in New York City; and the *Scientific Departments of the Cornell University* at Ithaca. This comparison by no means, implies that New York is doing little or nothing for *professional* Scientific instruction. It does, however, at this point, suggest the vital question: How can these worthy, and, some of them, long established *beginnings*, best be completed?

Within the brief limits of an article, this question can best be answered by a few preliminary general explanations, followed by a brief discussion of some one representative example.

"Scientific Schools," then, are, first, either simple or compound. By a simple school is meant one which gives but one professional course and degree. Medical schools, and schools of mining, only, are examples to the point. By a compound school, is meant one, which gives several parallel courses of study, and corresponding degrees. Such are nearly, or quite all scientific schools in the United States.

Again: from another point of view, the engineering, and other scientific schools of this country, are either independent, or component schools. The former are separate organizations. The latter are component parts of larger organizations. Thus, the *Institute of Technology* in Boston, and the *Polytechnic Institute* in Troy, are independent schools. The *Sheffield School* at New Haven, and the *Engineering Department* at Union College, are components of Yale College and of Union College.

Further: There is a marked difference between the technical schools, in respect of the requisite age for admission to them, considered as indicative of the relative elevation of their courses of study. Thus, boys of fourteen, are admitted to the Chandler Scientific School of Dartmouth College, while at Troy, the required age is nominally sixteen, and virtually over eighteen, as shown by the records for several recent years; and, as the two institutions are not known to come into any disadvantageous competition with each other, it may be said, not ungraciously, that a comparison of their published programmes will show a corresponding difference in the scope and range of the studies pursued.

Schools, again, differ greatly in relative wealth, as seen in the opening statements of this article, though, if we include moral elements, those institutions which are poorest in material things, may, like many individuals similarly conditioned, be the wealthiest in elements of power to shape and enrich and strengthen the minds which yield to their formative influence. There is, perhaps, no proposition concerning life, which does not need to be received with thoughtful discrimination; and it is certainly true that great invested resources, sumptuous edifices, and ample equipments, do not, of themselves, necessarily make a superior institution, while they *may* even have no better effect than the contemplation of Babylon had upon Nebuchadnezzar. Nor is this remark a jealous sneer at the wealthier institutions. Each one of them is welcome to all it asks for. The success, throughout the land, of the course of professional education in science, in which all the technical schools are alike engaged, is better than the success of any one school. It is only declared that the material resources of each institution, whether greater or less, are truly valuable or not, to it, and, through it, to the public, according to the purposes for which and the spirit and energy with which they are wielded.

Lastly: if only for the sake of doing honor to one of the ornaments of New York State, and, indeed of the Nation, it must be noted that scientific schools, like others, differ, as existing either on the principle of *reciprocity*, by which the student pays a sum partly, at least, representative of what the training received is worth to him; or on that of *benevolence*, by which the pure, earnest, and capable youth, who is appointed to do battle with poverty, is helped, by his stronger brother, to those things which are beyond the compass of his purse, but not beyond that of his mind.

The Rensselaer Institute heads the list of the former class of schools, by the high tuition which its uncompromising thoroughness enables it, and its lack of any invested endowment compels it to demand. The Cooper Institute of New York nobly represents, in the scientific field, the agencies which exist to give, to the struggling, a fair footing in life.

These radical grounds of distinction among schools, have so multiplied at our pen point, while it has traced them, that there is little space left in which to discuss actual examples, in the light of these distinctions.

We take the Institute at Troy as the best representative example, because, it is not only the oldest and best known in the country, but is also the ripest for a new reorganization. Founded as early as 1824, it has had upwards of four hundred graduates, nearly three hundred of whom are living, and many of whom have become, or are becoming distinguished. It has now in operation, though not on a large scale, three of its four proposed four years' courses; viz., that in civil engineering, for which it has long been especially celebrated; that in mining, recently established; and that in natural science. It only needs a comparatively moderate increase of men and means to enable it to meet the growing demand for its published course in mechanical engineering; since its admirable location, in a centre of varied manufacturing industry, furnishes it with actual machines at work, in place of costly cabinets of models, useful as these must everywhere be, to a certain extent. In its civil engineering course, also, it illustrates the superiority of practical examples over models, when the former can be had. A score or more of widely different wood and iron roof and bridge structures are right at hand, and on such a scale as to invite interested scientific investigation, or practice in drafting; while a noble river, with numerous islands; and a sharply defined bordering hill region, broken by many ravines, afford such practice in both topographical and hydrographical engineering field operations, as cannot so well be had in door yard exercises, or on prairie levels: In mentioning the ripeness of the Institute for a new re-organization, allusion is made to the fact that it was mainly a school of National Science—Geology, Botany, etc.,—until 1849, when it was re-organized as more distinctively an engineering school, with a course of two years; which, by a process of natural growth, quickly expanded to one of three, and, soon after, to one of four years. Also to the fact that, to-day, it is doubtless the ripest existing school of its kind in America for a re-organization with a five years' course, in two main divisions; first, an elevated preparatory course in general science and modern languages, of three years, to be followed by high and strictly professional courses of two years each, for the degrees already contemplated, and, in addition, a course in *Architecture and Building, both civil and naval.* Such a two fold five years' course, would doubtless ultimately expand to one of seven years: All of which taken in connection with the preceding principles, only leads directly to the conclusion, which it is the main object of this article to establish, viz., that with the existing number of *unfinished* scientific schools in the country, of which the Troy School, with all its characteristic advantages and disadvantages, is but one, it would be far better to develop to organic completeness these existing institutions than to further multiply costly experimental beginnings.

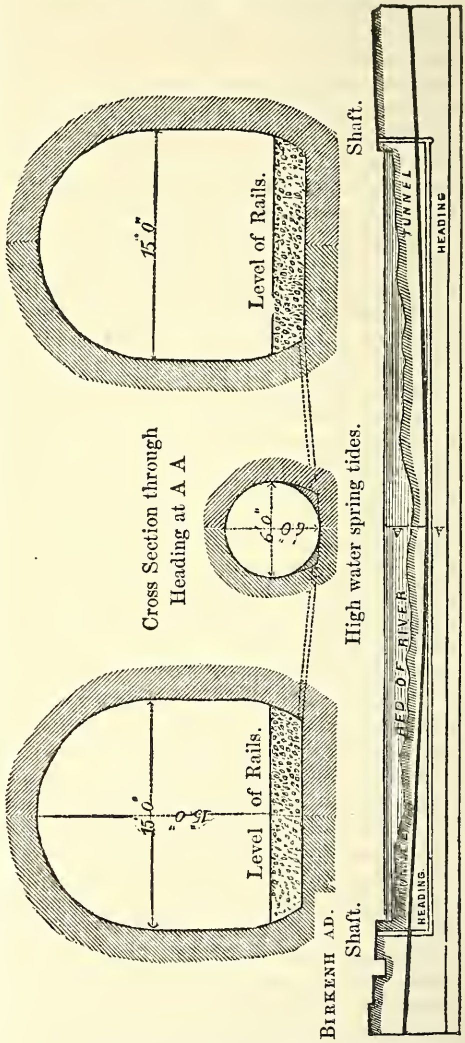
THE WROUGHT IRON MANUFACTURE.—We learn that anthracite coal slack, and even sand and ashes, have been substituted for ore, in the Ellershausen process, with good results. The decarburization was, of course effected by the fettling ore; the coal both separated the particles and increased the heat, thus facilitating the chemical reaction; the ashes and sand probably merely loosened and divided the mass for the better action of the fettling.

THE PROJECTED MERSEY TUNNEL FROM LIVERPOOL TO BIRKENHEAD.

PARTICULARS OF COST—CHICAGO TUNNEL AND OTHER WORKS.

By Sir CHARLES FOX.

From the "Quarterly Journal of Science."



As a means of inter-communication between Liverpool and Birkenhead, a tunnel beneath the Mersey has been under consideration by leading men on both sides of the river for upwards of thirty-eight years; and when the inconvenience and loss both of time and money which the want of such means of transit has ever occasioned are considered, it is, in these days of increased facilities, a matter of surprise that, while works of real difficulty have been carried to completion on every side, this obvious want should not have been satisfied.

There is but one opinion as to the importance of inter-communication between Liverpool and Birkenhead, and it being admitted that the great obstacle in the way of its realization is the doubt existing in the public mind as to the cost at which it can be attained, it has been felt that this doubt can never be overcome unless the nature of the river bed is conclusively proved.

When this has been done, I am sure that the construction of a tunnel through the red sandstone rock under the Mersey will be found an easy and inexpensive operation, as judging from the many similar works which have been executed in this rock during the last forty years, (those most analogous having been tunnels of various dimensions, carried on at considerable depth below the level of the bottom of the river, with a view of obtaining a more copious supply of water for the town of Liverpool,) it has been ascertained that in no material can such works be effected at so small a cost as through the very strata now well known to exist in this locality, the amorphous nature of the rock rendering it peculiarly advantageous for tunneling operations.

Tunnels have been made at a low price through chalk, as that material is readily excavated; but from its general looseness and its consequent tendency to fall, it is deemed necessary, for the purpose of ensuring safety, to put in brick or stone lining, and this, as compared with red sandstone, which generally requires no such lining, considerably augments the cost; and it must not be forgotten that the sandstone, when excavated from a tunnel in or near a town, is saleable for use as building material, while chalk taken from a tunnel, being of no value, is more generally run to spoil.

It would appear that one of the most formidable hindrances in the way of getting capitalists to embark their money in making tunnels under rivers, of which very many are urgently needed, arises from the disposition which undoubtedly exists to form an unfair comparison between such works and the Thames Tunnel, which, as every one conversant with the circumstances connected with it will know, cost a very large sum, although passing under a river of no considerable breadth. This, however, is no fair criterion upon which to judge of any other case. This tunnel was constructed some forty years since, when the science of tunnel making was but little understood, and when it had to be applied upon a very limited scale, without the advantages arising from many later improvements, and without the extensive experience derived during the last forty years from works of this nature, required in the development of the railway system all over the world.

This makes a comparison deceptive, to say nothing of the Thames Tunnel having to be constructed under all the difficulties of passing, not through London clay, which it would have done had it been placed a few feet deeper, but through the treacherous and loose silt and gravel of the bed of the river Thames, while the tunnel which forms the subject of this paper will pass through solid rock.

To attempt to draw a comparison between this project and the Thames Tunnel is but to show an entire want of acquaintance with the relative circumstances of the two cases, for it must be borne in mind that the Act authorizing the construction of the latter received the Royal Assent on June 24, 1824, more than forty-four years since, and that the tunnel was not opened for passenger traffic till March 25, 1843, having occupied a period of eighteen years and three-quarters in arriving at completion.

Were this work now taken in hand by an engineer possessing the experience obtained in constructing tunnels since the period above referred to, taking care to place his work deep enough to let it pierce only the London clay (to have done which the present tunnel ought to be fifteen feet deeper than it is), no doubt the entire work could be completed for little more than a tithe of the cost (which was £454,700), and need not certainly occupy a longer period than two years, as is proved by the following facts:

The excavation for the Thames Tunnel commenced in December, 1825, and all went on satisfactorily until May, 1827, when the upper portion of the works protruding above the London clay into the gravel and silt of the bed of the river, the first irruption of water took place, there being then a length of 545 ft. of the tunnel constructed, which had been done in a period of seventeen months; so that, had no casualty occurred, and assuming that the rate of progress was not, as it no doubt would have been, augmented by the natural increase which always follows a better knowledge of any work, the whole 1,200 ft. would have been completed within three years and two months; and this, be it remembered, would have been the result if made wholly from one end; whereas, with the present increased facilities and knowledge of the operation, it would have been carried on from both sides simultaneously, when, even at the then slow rate of progress, the time would be reduced to one year and seven months; so that there can be no doubt that, with present appliances, the work of the tunnel could, with perfect ease, be completed in one year and a quarter; and taking for the shafts and other matters, say, half a year more, the whole could with convenience be accomplished in one year and three-quarters.

In order to clear up every doubt, I propose, at an estimated cost of £20,000, to drive a heading under the Mersey from shore to shore, a distance of 1,300 yards, and thus not only to prove the practicable nature of the larger and more complete undertaking, but also the future cost, while at the same time providing the necessary drainage and ventilation for the permanent works.

The first operation will be to sink a shaft on either side of the river, on land belonging to the Mersey Docks Board, to a depth of about 120 ft. below the surface (see plate, lower figure). The shaft on the Liverpool side will, for a depth of say 40 ft., pass through made ground, and will then enter, and for the remainder of its length be entirely through, the solid rock. That on the Birkenhead side will be in solid rock throughout. These shafts will be about ten feet in diameter, and will terminate in large sumps for pumping purposes. At each end will be erected permanent pumping engines and pumps of sufficient power to deal with the largest quantity of water that is likely to be met with, and which pumps will not only be used during the construction of the works, but be adapted for keeping the main tunnels permanently free from water. Winding engines will also be erected of sufficient power, not only to deal with the material excavated from the heading, but also with that from the tunnel itself.

The shafts having been sunk to the full depth, and the machinery fixed, the heading will be commenced from either end, and driven much in the same way as an ordinary mining water level. It will have a very slight rise towards the middle of the river, so as to drain both ways into the shafts. Judging from experience, I expect that at least four yards lineal a day will be driven at either end, giving a total of 160 working days, or thereabouts, for the completion of the heading after the shafts are sunk. I have taken much pains to collect evidence as to the nature of the rock through which the heading will pass, and have found every one conversant with the subject unanimous upon the point. The general result of my inquiries and observations cannot be more forcibly explained than by the following summary of evidence given before the Referees of the House of Commons in 1865.

The late Mr. Thomas Duncan, then engineer to the Liverpool Waterworks, stated that he knew well the nature of the rock, which is not very porous. He did not think the quantity of water produced from the rock at Birkenhead and Liverpool would make the tunnel a difficult work of construction, and he did not believe there would be any difficulty in carrying it through, so far as water is concerned. He considered that the "faults" existing in the sandstone rock, and shown on the geological map, were advantageous, as he had cut through many of them (having excavated in the red sandstone at various points over sixty square miles), and had nearly always found them filled up with a species of concrete, which was perfectly water-tight. In a few instances, however, he had found them filled with laminated rock, having a saccharine appearance, and evidently having been subjected to a great heat, and yet water-tight.

Mr. James Abernethy, C. E., stated that, having been engineer to the Birkenhead Docks, he had large experience of the sandstone rock, of the same character as the rock excavated from the Birkenhead Docks, which is a close, compact, strong stone, suitable for building purposes.

Mr. John Fowler, C. E., stated that in framing his estimates he had well considered the question of possible faults in the rock, and, on the whole, preferred to have faults of the character known to exist in the red sandstone at Liverpool and Birkenhead, as they, being impervious to water, back up and limit in area the water contained in the interstices of the rock. The faults are filled either with clay or with some vitreous material. Mr. Fowler further stated that he considered red sandstone at all times the best material to construct tunnels through.

Besides the above testimony, there is the further fact that Mr. John Hawkshaw, C.E., F. R. S., proposes to construct a tunnel under the Mersey, near its mouth, where the river is very wide and the character of the rock less certain; and it is therefore evident that engineers of eminence are agreed in considering the work of making a tunnel thoroughly practicable, and that at a moderate cost.

As much doubt has been expressed as to the possibility of driving the heading for any such sum as £20,000, I would remark that the Trustees have before them a tender from a responsible contractor, who is prepared to undertake to complete the work considerably within that amount, finding all necessary plant and machinery, and giving approved security to the extent of £5,000.

Again, the chief item in the cost of this work is that of excavation, and the engineers already mentioned, and who gave evidence before the Referees, were agreed in considering 9s. a cubic yard an ample price for this work in the tunnel, including all possible contingencies, being, in fact, three times the cost of similar work under ordinary circumstances. I have, however, taken 20s. per cubic yard for the excavation in the heading, which I believe to be far more than it can cost.

That a tunnel, or, as it is called, a subway, can, in the estimation of those competent to form an opinion, be carried under the river Thames at a very small cost is, I think, proved by the fact that Parliament, last session, passed an Act for the "Lower Subway" proposed by Mr. P. W. Barlow, F. R. S., C. E., son of the highly talented Professor of Mechanics of that name, the capital for which is but £12,000, with power to borrow £4,000.

This work is now in course of construction, and is to consist of an excavation through the London clay 440 yds. in length, lined with cast iron cylinders $\frac{7}{8}''$ thick, with strengthened flanges, whose external diameter will be $7.1\frac{3}{4}''$, or 7 ft. inside. At each end there will be a vertical shaft between 50 and 60 ft. deep, fitted with lifts for the purpose of raising or lowering passengers from and to a saloon carriage, which will at very frequent intervals pass through the heading for the conveyance of passengers.

From each end the subway will fall towards the center of the river at an inclination of about 1 in 40, to a level under the river, where the rails will be at a depth of 61.6 below Trinity high water mark.

With regard to the above, it may no doubt be said that it is as yet only a matter of estimate; and though given by an engineer of standing, and approved by Parliamentary committees—one of whose special duties it is to investigate the estimates, for the purpose of testifying to their sufficiency—yet the estimates might prove fallacious. I now, therefore, proceed to give the cost of an important work at Chicago, completed some time since, and in many respects analogous to the one of which I am treating, but beset with some difficulty not to be encountered in passing under the Mersey, arising in great measure from the more uncertain material through which the heading had to be driven; that at Chicago being clay, and that at Liverpool red sandstone—the one being driven for two miles, or 3,520 yards, under Lake Michigan, the other only 1,300 yards under the river Mersey.

The Chicago tunnel was made by Mr. Cheeseborough, C. E., engineer to the municipality of Chicago, for the purpose of obtaining a more ample supply of pure water for the inhabitants of that important city, from a point beyond the reach of sewage contamination; hence its great length.

This work, embracing as it does two miles of heading, carried through clay, lined with two rings of brick-work, including a sum of $120,000 expended on the two shafts and the appliances connected therewith, cost $380,000, or £76,000.

The above amount spread over the 3,520 lineal yards of heading, gives £21 11s. as the cost of each lineal yard, and deducting therefrom £7, the value of the additional excavation, centering and brick lining (not found necessary in tunnels in the red sandstone), it will bring the price per lineal yard to £14 11s., without taking into account the more than double value of labor at Chicago, which has unfortunately greatly augmented the outlay upon this work.

Now, £20,000 expended upon 1,300 lineal yards of heading under the Mersey, gives the price for each £15 5s., so that, in drawing a comparison between the two works, a greater sum has been taken in the estimate for the one than has been actually expended on the other, and this is assuming the price of labor to be the same in both instances, which, however, is by no means the case, that at Chicago being very high.

I may here allude to a very interesting and instructive work, also very analogous to that proposed under the Mersey, which has been carried to a satisfactory conclusion at Attock, on the Khyrabad Pass, in India.

It consists of a heading 600 yards long, 6 ft. sq., driven under the river Indus, through a rock which forms its bed, at a depth of somewhat over 90 ft. below the surface of the flood water.

It has been carried on by a few laborers, under the charge of Mr. Robinson, who have succeeded in filling up the fissures they met with during the operation by simple "feather" wedging of wood, and have, by this expedient, been able to keep back all the water which otherwise would have flowed into the heading with a force due to the whole superincumbent column.

The cost of this work has been about £13,000, and spreading the whole outlay over the 600 yards, brings out the cost to about £21 14s. per yard, which goes to prove that had the labor expended upon it been paid for only at English prices, it would have been executed at a considerably smaller cost than that arrived at by estimate for making the heading under the Mersey.

I have lately constructed a water level nearly one-third of a mile long, through harder rock, yet far less compact and more broken up, having much larger feeders of water than any to be expected in the red sandstone. In driving this heading and the shafts connected therewith, single feeders were met with yielding 1,000,000 gallons per diem, yet these were dealt with without serious difficulty or expense, the cost not having been one-half that estimated for the Mersey work.

In driving the heading a boring-rod would, as is usual in water-bearing strata, be kept ahead of, and at the top of, the work, and thus due notice would at once be given of any unusual feeder of water, should such exist.

All ordinary cracks in the sandstone are readily made water-tight by the use of a "feather" wedge of timber tightly driven into them. If a large crack were met with, containing water (a most unlikely thing, as has been already shown), a lining of iron would be put into the heading, and pushed forward as the excavation proceeded, until the fault was passed.

The heading will be circular, and six feet in diameter.* It will, when completed, be available not only for draining the tunnels, but for telegraphic purposes, and probably also for conveying water from the Welsh lakes to Liverpool, thus avoiding a lengthened *détour* and most expensive works.

The heading having been successfully driven, I am confident that there will be no difficulty in letting a contract for a double line of railway under the river Mersey for £100,000, which would, indeed, give a price of £77 per lineal yard of tunnel—the work being through good hard sandstone, and thoroughly drained by means of the heading; whereas, £60 a lineal yard is a large price for tunnels, even through clay, where, of course, heavy lining, including an invert, is required.

The river tunnel being completed, the remaining works necessary to bring the two towns of Liverpool and Birkenhead into complete communication with each other will be of a very ordinary kind, and free from any unusual contingency.

Under the existing Parliamentary powers, the railway can be completed in a direct line from Church st., Liverpool, to Woodside, Birkenhead, with an intermediate station at the bottom of James st., and by its means, and by trains running every few minutes, passengers will be conveyed between the termini in six minutes. The authorized line runs entirely either under the river or under streets, and not a single house will be taken for the railway itself, and only one or two for station purposes. The railway can be readily constructed without interference with the traffic of the streets. The main line will be double, with extensive sidings for goods, in direct communication with the dock lines on either side of the river.

Surveys have been completed of extensions, whereby the Mersey Railway can be made to form a direct connecting link between the important railway systems on either side of the river, and this at a moderate expense, and with the destruction of hardly any property.

The effect produced by the opening of this railway will be very great. The docks of Liverpool and Birkenhead, now under the same management, form the noblest emporium of trade in the world, but their joint usefulness is much impaired by the want of satisfactory communication between the two sides of the river; and the immense resources of Birkenhead, developed at a cost of £7,000,000 sterling for docks alone, are lying comparatively idle, whilst the quays and docks on the Liverpool side are flooded

* See Plate. It is unnecessary to give any detailed description of the Plate, as it explains itself.

with a trade increasing daily, and already over-tasking their capabilities.

More dock and quay accommodation must be found. On the Liverpool side, to construct fresh docks, either north or south, is to place them miles away from the center of trade—at the north, in a very exposed situation, almost unapproachable in heavy weather; at the south, only available for vessels of comparatively small draught—what then so natural as to utilize the expenditure at Birkenhead, now yielding but a nominal return, but which, with the Mersey Railway completed, would be placed in a very different position. The Birkenhead docks and warehouses would then, as regards both passengers and goods, be placed within a few minutes, in all weathers, of the heart of Liverpool.

The immense traffic to be expected under such altered circumstances may be inferred from the fact that with the present imperfect means of communication, often brought almost to a standstill by a fog or a gale of wind, twenty millions of passengers, at least, pass over the ferries annually.

The Cheshire side of the Mersey abounds with pleasure sites for residential purposes, and not only New Brighton, but many other places would experience an immediate increase if railway communication were established. Thousands of persons who would prefer a residence on that side, are at present deterred by the difficulties of the daily crossing to their places of business.

The construction of this railway and its extensions, would also place Liverpool in direct communication with North Wales and Holyhead.

Liverpool, Birkenhead, and their surroundings now contain at least seven hundred thousand inhabitants, and the steady increase of population renders means of communication every day more urgent.

If this railway be not soon completed, an immense expenditure must be incurred to improve the approaches to the landing stages, which will, after all, not get rid of the most serious inconveniences connected with the ferries, which are chiefly caused by fogs and storms.

Those who have interested themselves in the Mersey Railway are in earnest in the matter, and if they meet with but moderate assistance from those locally concerned, Liverpool and Birkenhead will soon be connected by a direct railway.

THE DYER COURT OF INQUIRY.

The Court convened last November to investigate the official conduct of Gen. Dyer, has made its report to the Secretary of War. The investigation extended over a vast amount of details, and was exhaustive on those points in respect to which the accused had been condemned by the Congressional Investigating Committee. All possible latitude was given to the accusors in the matter of evidence, they being allowed to produce both oral and documentary evidence, and permitted to appear and to be represented by counsel. Several of them were heard as witnesses in support of the allegations, and "it is believed that no evidence offered has been excluded, which could possibly have shed any light upon the questions involved, or which would have affected the decision of the Court." The high character of the members composing it, viz., Gen. George H. Thomas, President, and Generals Terry and Hancock, members, and Gen. Joseph Holt, Judge Advocate, makes the decision unquestionable, and will settle all doubts in the minds of unprejudiced readers. The Court acquits Gen. Dyer of all the charges against him. The charge of receiving a royalty for the purchase of Absterdam projectiles was not sustained by the Court, its only foundation being a remark made by Gen. Dyer, to the effect that if anybody was entitled to a royalty, he himself was. The Court say that "the remark, if ever made by Gen. Dyer, was made to Mr. and Mrs. Dickson, *some time after* the only order ever given by him to Dickson & Lane had been issued. [This order was only partially filled.] The whole conduct of Gen. Dyer in reference to this contract and the payments thereon seems to negative the idea that he had a corrupt motive in giving the contract, or became in any manner interested in it. The evidence as to Gen. Dyer's assertion in the matter of royalty, was either the pride of an inventor, or a desire to protect the interests of the United States. It is established by the testimony that he always held the opinion that the Government should, of right, have the privilege of using, free of charge, any invention that might be made by an officer in the public service, and that he had acted upon this principle when, in 1861, the temptation was presented of a large sum offered to him for a patent right, to be taken out by him on a shell of which he seems to have claimed the invention, to be then transferred to other parties. He declined to do so, alleging that if the invention was of any value, the use of it belonged to the Government, and "there was not money enough in the country to buy it of him."

With reference to the charge that the displacement of Gen. Ramsay, and the appointment of Gen. Dyer had been procured by an intrigue, in which officers of the Ordnance Department were concerned, the Court finds from the evidence, and especially from the testimony of Secretary Stanton and Asst. Secretary Watson, that it is without foundation. "Mr. Stanton stated that Gen. Dyer never solicited the position from him, but 'that he ordered it of his own notion,' and that he does not think that any human being knew of his determination to appoint Gen. Dyer, until after he had concluded to recommend him to the President, except himself and Assist. Secretary Watson." Mr. Watson testified that the President told him "that he had concluded to nominate Gen. Dyer to the position, not upon any political or personal consideration, but solely with reference to his professional merit, and the requirements of the service."

The findings of the Court are equally explicit upon the other points charged, and the whole country will not only congratulate Gen. Dyer upon the triumphant vindication which his own conduct has received, but will congratulate itself also upon finding such integrity in one of its most responsible public servants. D.

MINING NOTES.

From the "Quarterly Journal of Science."

The project for organizing a Colliery Insurance Company, to embrace a provision for the survivors of those killed in colliery accidents, and to reimburse the colliery proprietor or worker for any loss accruing to his property, is again exciting attention. A letter has been published by Mr. Stephen Sleigh, of Austin Friars, which clearly shows the practicability of such a system of insurance. We learn from this letter that the value of the colliery property of Great Britain is estimated at £70,000,000 sterling. The production of coal is at present 104,000,000 tons per annum, and in obtaining this, on the average of ten years, 1,000 lives are lost in each year. It appears that two pence per week per man would produce a fund from which £100 could be given to widows and children of the deceased collier, and that a very small premium, varying of course with the district, would secure the insurer from any serious loss to his property. As active measures are about to be taken to establish this most important principle, we content ourselves at present by directing attention to the movement.

Coal in the Colorado district is a matter of great importance. According to the "Denver News," General Pierce stated to the Board of Trade that besides the bed of 31 in., discovered near Fort Supton, on the Platte, there were also two beds on the Cache-la-Poudre. One of these beds was 4 ft. thick, and the other about 18 in. The "Salina Herald" says that in digging a well on the east side of the Smoky Hill River—less than two miles from town—a bed of good bituminous coal, 18 in. thick and about 20 ft. below the surface, was cut through.

Coal mining in France has, during the past year, been particularly active. This will be seen from the following statement of the production during each of the last six years:

	Tons (statute).		Tons (statute).
1863	10,516,752	1866	11,807,142
1864	11,001,249	1867	11,975,164
1865	11,785,714	1868	12,345,000

The colliers of Belgium have not exhibited the same progressive increase. From the report of Mr. F. Iocham, Director of Mines in the Province of Hainault (which is the last published authority on the production of coal in Belgium), we learn that to the end of 1867 the production was as follows:

	1865.	1866.	1867.
Hainault	9,206,058	9,831,424	9,595,280
Namur.........	305,754	358,687	389,586
Liége..........	2,328,911	2,564,551	2,770,956
Total of the kingdom in metrical tons......	11,840,723	12,754,662	12,755,822

The copper mines of Africa have of late years been attracting considerable attention. The copper lodes in the Insiziva Mountain, about twelve miles from the southern boundary of Natal, are remarkable. Some comparatively small workings have been carried on about 80 miles from Port St. John. The deposit here is described as about 18 ft. thick by $2\frac{1}{2}$ ft. in depth. From this description it is evidently not a *vein* but a *bed*. This is clearly in a state of decomposition, since it is said that ore is replaced by a yellow ocherous deposit (*gossan* of miners) containing nodules of very pure carbonate of copper or malachite, varying in size from a pea to masses of 10 or 15 lb. weight. Some miners from D'Urban penetrated deeper into the mountain, and again found a similar deposit. Portions of considerable masses have been found to contain as much as 56 per cent of metal, the average, however, being from 30 to 40 per cent. Silver was found to the extent of 5.30 ounces to the ton of copper, and a trace of gold was detected.

Chromium is stated to have been discovered in large quantities in Maryland and Pennsylvania. Chromate of iron, of fine quality has also been found in Victoria. We understand samples of this mineral and antimonial ores, of good quality, have been shipped to this country with a view to determining their real commercial value.

In a cave in the mountain of Galenstock, which it is well known separates the cantons of Berne and Urich, a valuable deposit of topaz has been recently found.

Tin mines in Siam are, on the authority of the "Journal of the Society of Arts," about to be worked. We quote the paragraph:

"Another tin district is about to be opened at the Isthmus of Kra. The immense value of the tin workings at Junk, Ceylon, or Phuket, supposed to be not less than 150,000 tons per annum, has incited a Chinese merchant to propose the active development of the Kra mines, and as tin is supposed to abound along the whole range of the Malay peninsula, there are many who believe in his success. He is to have the government of the district to enable him to carry out his designs. The river of Kra is the southern boundary between British Burmah and Siam."

Seeing that the annual production of tin is as follows:

	Tons.
England	7,296
Banca	4,260
Billeton	1,900
Other parts	3,000
Total	16,456

—the 150,000 tons said to be produced at Junk is an evident absurdity. During the past year the Chinese merchants have been the largest buyers of British and Dutch tin, to which circumstance we owe the rapid rise in the price of tin which has lately taken place. This proves that they have not any great expectation of very considerable production of this valuable metal nearer home.

The prominence which has been given to technical education has led to a proposal to found a Professorship of Mining in the University of Glasgow; and a deputation has been in communication with Professors Ramsay and Huxley, of the Royal School of Mines, on the question of establishing a mining school in Wales. The experiments made already in Glasgow, at Bristol, and by Sir Charles Lemon, and others, in Cornwall, should teach the lesson that it is quite impossible for the miner to attend any fixed central school. The only practical and useful system of imparting instructions to the miners is that—adopted with great success by the Miners' Association of Cornwall and Devonshire, and by Mr. Dagliesh, in the neighborhood of Seaham — of sending the teacher to the miner, and giving him the advantages of a school of mines in the very midst of the district in which he labors.

GOLD.—The Nova Scotia gold fields have produced during the past three years as follows:

	Ounces.
1866	25,204
1867	27,314
1868	20,733

The production of the quartz rocks of Merionethshire has fallen to 490 ounces in the period between October 1st, 1867, and December 31st, 1868.

There has been a small rush to certain gold fields in Sutherlandshire. On a district not far from Helmsdale, which was known only to a few sportsmen and shepherds, recognized as the Kildonan Burn, a regular system of "diggings" has been organized, and the burn has been christened as "Gold Creek." The results are not, however, satisfactory, since it appears that the most industrious gold-seeker cannot realize more than five shillings a day.

THE HEATON PROCESS.—Considerable differences of opinion still prevail as to the value of the Heaton steel-making process noticed in our last number. We have carefully read and considered all that has been said in favor of the process, and against it. We are not by any means satisfied with the tone which has been assumed by those who have entered on the discussion of the question. Indeed, it is to be regretted that many of the statements which have been copied from paper to paper should ever have been made at all. They are obviously not consistent with our knowledge of the chemical changes effected in a mass of iron when subjected to the action of nitrate of soda. We have been informed by one of the largest of the Sheffield steel manufacturers, that, while he waits to see the result of a continuance of the experiments carried on at Langley Mills, before he adopts it, he is strongly predisposed in favor of the process; that he regards it hopefully, and, we are bound to say it, that he is greatly pleased with the liberality and openness observed by Mr. Heaton. With these remarks, which we introduce mainly to convince our readers that we are not inattentive to the experiments in question, we leave the Heaton steel process until its more complete development removes it from the doubful position in which it has been placed by injudicious advocacy.

A discussion of some interest in connection with the Heaton process has been opened in the pages of "The Chemical News." It arises out of a paper read before the Chemical Society, by Dr. B. H. Paul, on "The connection between the Mechanical Properties of Malleable Iron and Steel, and the amount of Phosphorus they contain." Mr. W. Mattieu Williams, of the "John Brown & Co. Limited" Works, Sheffield, argues that Dr. Paul has shown an imperfect knowledge of his subject. That although Dr. Paul's conclusion that 0.50 per ct. does not impair the quality of steel, is correct when it applies "*to tenacity as measured by a direct and gradually applied longitudinal or axial strain*," yet that it is absolutely wrong when it is made to refer to steel which is to be employed for cutting instruments of any kind. "It is obvious that the power of resisting a sudden, a vibratory, and a transverse shock is the property most demanded," and that here the smallest quantity of phosphorous is highly injurious; "this is just the property which phosphorus tends to destroy."—*Quarterly Journal of Science.*

COMMUNICATION BETWEEN PASSENGERS AND GUARDS.—Under the provisions of an Act of Parliament, passed last session, all trains running distances of twenty miles or more, without stopping, must, after April, 1869, be supplied with some sufficient means of intercommunication between passengers and guards. With a view to test the different means for accomplishing this object, some experimental trips were undertaken on the line between York and Scarborough, at the latter end of November last, and on the London, Chatham and Dover Railway, between London and Seven Oaks, during the following week. Three systems have been proposed for the purpose, viz: 1. The rope pulls, which is the oldest of them all. 2. The electrical signalling system, of which there are many varieties, and some of them have already been in use for a length of time on the various lines of railways; and, 3. The pneumatic system, which, whilst it is the newest, is also in many respects the most efficient. Space will not admit of our giving a detailed description of the several systems that were submitted to trial. The principle of the rope and electric bell system will probably be well known to most of our readers, and we shall not therefore make further reference to them here. The pneumatic system, being novel, may, however, claim a brief notice. The signaling apparatus consists of a heavy gong upon the engine or tender, and a smaller one in the guard's van. Both these gongs are struck by hammers, which receive direct motion from the train when a signal is given. When no signal is passed from passengers or others, these hammers are kept away from the gongs, and they are put into gear in the following manner. A tube runs along the whole train, beginning at a pump in the tender, passing from carriage to carriage, and ending in a plug at the back of the train. This pipe, which is worked by the machine, keeps pumping the air out of the pump, and sustains in it a partial vacuum. Underneath those vehicles, which are supplied with gongs, there are shallow cylinders in connection with the vacuum tube, from which, the air being exhausted, their pistons are drawn backwards, and pull thereby the striking portions of the bells out of gear. Over each compartment a T-piece is inserted in the tube, and a plug is fitted into its lower stem so as to keep the tube air-tight. The passengers give signals by pulling out these plugs, and this, breaking the vacuum, causes the bells to fall into gear.

That the pneumatic principle possesses many advantages over the other two, both as to certainty of action and from its non-liability to be tampered with, is beyond a doubt; but the committee of Railway Managers have nevertheless recommended the rope system, probably on account of its cheapness, and their recommendations have been accepted by the Board of Trade.—*Quarterly Journal of Science.*

PAPERS ON CONSTRUCTION.

No. II.

By Lieut. C. E. DUTTON.

(Continued from page 311)

13. Resuming the expression derived, Sec. 9, from the consideration of the resistance of a cross section to rupture by a transverse force, viz: $\frac{s\,b}{x}\int x^2\,d\,x$, and noting that the resistance to compression is equal to that to extension, so that the expression becomes $\frac{2\,s\,b}{x}\int x^2\,d\,x$, and substituting $d = 2\,x$, and integrating

$$R = \frac{2\,s\,b}{x}\int x^2\,d\,x = \frac{1}{6}\,s\,b\,d^2,$$ and the moment of inertia $M = \frac{1}{12}s\,b\,d^3$.

These equations are founded upon the assumption that the beam has a symmetrical section with reference to the neutral axis. In cases where the cross section is otherwise, the position of the neutral axis remains to be determined. Since the moments on both sides of this axis, whatever its situation, must be equal and opposite, this axis must pass through the center of gravity, for no other condition will satisfy such an equation of moments. The only obvious method of determining such a case seems to be to resolve the cross section into a number of geometrical figures, the positions of whose centers of gravity with reference to the center of gravity of the whole mass may be readily determined, and thus find the moment of inertia of each component figure with reference to the neutral axis of the section. The whole moment will be equal to the sum of the moments of the components, and the moment of any component is equal to the moment of its area with reference to its own neutral axis, added to the product of its area into the square of the distance between its own center of gravity and that of the whole section. Let $A' =$ the area of a subdivision, m' its moment of inertia with reference to its own neutral axis, and x' the vertical distance between its center of gravity and that of the section; then the moment of the whole section

$$M = \Sigma . m' + \Sigma\,A'\,x'^2.$$

The following example is given by Prof. Rankine for calculating the strength of the Hodgkinson beam. It is assumed to give way by the tearing of the lower flange. The following are the dimensions:

	Area.	Depth.
Upper flange,	A'	h'
Vertical web,	A''	h''
Lower flange,	A'''	h'''

Total, $A'+A''+A''' = A$, $h'+h''+h''' = h$.

The determination of the position of the center of gravity will show the distance of the neutral axis above the bottom to be

$$x' = \frac{h}{2} - \frac{(h''+h''')A''' - (h'+h'')A' - (h'''-h')\,A'}{2\,A}'$$

and the moment of inertia of the section

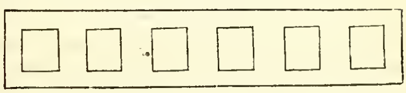
$$M = \frac{A'h'^2 + A'' + h''^2 + A'''h'''^2}{12} + \frac{1}{4\,A}\ \{A' A'''(h'+h'''+2\,h'')^2 + A'A''(h'+h^2)^2 + A''A''' (h''+h''')^2\},$$

and the moment of resistance

$$M' = \frac{S\,M}{x'}.$$

14. The formulæ of transverse strength thus deduced are in conformity with those obtained by the best authorities on this subject. Mr. W. H. Barlow, however, has shown conclusively that there enters into the strength of beams another factor not hitherto discussed, and which is dependent on the resistance of the beam to flexure. It was found in the case of cast iron beams that the calculated force was less than half the force actually necessary to rupture the outer fibers of a beam, and in speculating upon the cause he was led to think it probable that the effect of the lateral action of the fibers or particles of a beam, or the cohesion of successive laminæ, constituted a resistance to flexure. To test this theory, which assumes that there is a resistance independent of direct tensile and compressive resistance, and varying as the deflection, there were cast a number of girders with rectangular openings (like Fig. V), all having the same sectional area in the upper and lower ribs, but the distances varying between them. In these girders the neutral axis would necessarily be in the center, and the circumstances of rupture would be the same in all except with respect to flexure.

FIG. V.



Let $a =$ the united area of the upper and lower ribs, a' the area of the intervening space, d the total depth, c the distance between the upper and lower ribs, l the length of bearing, W the breaking weight, and F the force required to produce rupture in the extreme outer particles or fibers. Then $a + a' =$ the total area of section, and $W = \frac{2\,d\,F}{3\,l}(a + a') - \frac{2\,c\,a'}{3\,l}\frac{c\,F}{d}$; $= \frac{2\,F}{3\,l}\left\{(a + a')\,d - \frac{a'\,c^2}{d}\right\} = \frac{2\,F\,a}{3\,l}\left(d + c + \frac{c\,2}{d}\right)$ and hence the value of F becomes

$F = \frac{3\,l\,W}{2\,a\,(d + c + \frac{c}{d}{}^2)}$, and if the strength depended only on the direct tensile strength, F ought to be constant and equal to the direct tensile resistance of the material, which in the beam used was about 18,750 lbs. It was found, however, when the beams were subjected to breaking weight that the value of F was much greater, and showed a close relation to, and probable dependence upon the amount of deflection. Other experiments upon solid beams gave similar results. Finally, a series of experiments was made upon beams having the same total depths, but with variable depths in the openings. These beams would have nearly the same amount of deflection when subjected to a breaking weight. They showed very conclusively that when the deflection is the same the resistance increases where the depth of metal in the beam is increased.

These experiments then elicited the following facts as regards beams formed of parallel bars, separated at given intervals by vertical ribs.

1st. That in every case the resistance, or the value of F, is greater than that due to the tensile strength of the metal.

2d. That with the same depth of metal in the beams, and the same bearing, the resistance is greater when the deflection is greater.

3d. That with the same deflection and the same length of bearing, the resistance is greater when the depth of metal is greater.

It follows then that there is an element of strength depending on the amount of deflection in connection with the depth of metal in the beam, or, in other words, dependent upon the degree of flexure.

Now, if from the value of F the tensile strength of the metal is deducted, it will be found that the remainder maintains nearly a constant ratio in each case to the depth of the metal multiplied by its deflection. It would appear then that F is composed of two factors, one constant and depending upon the resistance to direct tension, the other varying directly as the degree of flexure.

Let $\phi =$ the resistance to flexure in a solid beam at the time of rupture, $D =$ the depth, $d =$ the deflection, $f =$ the tensile resistance, and $F =$ the total resistance. Then in a solid beam $F = f + \phi$. Also let F', d' and D' represent the total resistance, deflection and depth, of a beam with an open section; then the resistance arising from lateral action varies as the depth into the deflection, and

$$F' = f + \phi\,\frac{D'\,d'}{D\,d} \quad . \quad . \quad . \quad (1)$$

The value of ϕ may be determined from this equation in two ways, first by supposing f to be a constant quantity, and, secondly, by supposing f and ϕ to have a constant ratio. Adopting the second mode, let 1 to m represent the ratio of f to ϕ, then, $f = m\,\phi$, and $m\,\phi + \phi\,\frac{D'\,d'}{D\,d} = F'$, or

$$\phi = \frac{F'}{m + \frac{D'\,d'}{D\,d}} \quad . \quad . \quad . \quad . \quad (2)$$

which ought to be a constant quantity in all experiments. The forms of beam employed in the experiments were of two kinds, solid rectangular bars and open beams or girders, both of cast iron. The value of F in one solid beam was found to be 41,709 lbs., and the value of f, from experiments on direct tension, 18,750 lbs., leaving 22,959 as the value of ϕ, so that the ratio of ϕ to f was about 1.00 to .81. The mean of a considerable number of experiments gave the mean ratio as 1 to $\frac{4}{5}$.

These results, though not exhibiting complete regularity, were sufficiently uniform to indicate that the assumed law of the variation of this resistance is a close approximation to the truth. In equation $2\,\frac{D'\,d'}{D\,d}$ represents the ratio of the depth of metal in each beam multiplied by its deflection to the depth of metal in the solid beam multiplied by its deflection. But the deflections, as might have been expected from known laws, were nearly in the inverse ratio of the total depths of each girder, therefore the degree of flexure, and consequently the resistance to flexure in each will be nearly as the depth of the metal, divided by the total depth of the girder, and we are thus enabled to obtain a formula for computing approximately the breaking weights of these girders without first ascertaining their deflections. Thus, if $a f$ be the resistance due to tension, and $a \cdot \frac{\phi D}{d}$ be the resistance due to resistance to flexure, then $W = a \left(f + \frac{\phi D}{d}\right)$ will be the united effect of the two resistances.

The following are the properties arising from this resistance to flexure:

1st. It is a resistance acting in addition to the direct extension and compression.

2d. It is evenly distributed over the surface, and consequently (within the limits of its operation) its points of action will be at the center of gravity of the half sections.

3d. This uniform resistance is due to the lateral cohesion of the adjacent surfaces of the fibers or particles, and to the elastic reaction which thus ensues between the portions of a beam unequally strained.

4th. It is proportional to and varies with the inequality of strain between the fibers or particles nearest the neutral axis, and those most remote.

15. Taking the equation of the moment of resistance of a cross section, and putting it in the form $2\, s\, b \int \frac{x}{d}\, x\, d\, x$, and in the place of $\frac{s x}{d}$ substituting $\frac{f x}{d} + \phi$, we have

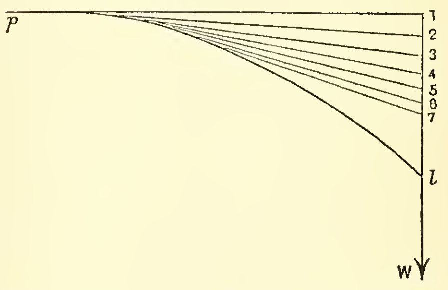
$$M = 2\, b \int \left(\frac{f x}{d} - \phi\right) x\, d\, x.$$

Integrating this between $x = \frac{1}{2}\, d$, and $x = o$, we have the formula $M = \frac{1}{2}\left(\frac{1}{3} f + \frac{1}{2}\phi\right) b\, d^2$. If, in the various expressions of the strength of cross sections of variable form, in the place of $\frac{1}{6}\, s$, we substitute the coefficient $\frac{1}{2}\left(\frac{1}{3} f + \frac{1}{2}\phi\right)$, we shall have corrected formulas for this new element of resistance, and much nearer the truth than those just given. The value of ϕ may be deduced for any weight from equation 2. The foregoing results having been obtained experimentally from cast iron beams, it might have been apprehended that the same would not hold good for wrought iron. The existence, however of a similar law in the case of wrought iron beams was practically demonstrated. But the relative values of f and ϕ are not so readily ascertained, because the material yields by crushing and not by fracture. Another point requires consideration, viz: that the ultimate compressive strength of wrought iron is but little more than half its tensile strength, while in cast iron the compressive is six times the tensile strength. But in wrought iron the force required to overcome the *elasticity* of the material is nearly the same in compression and extension; the difference being that the force which overcomes the elasticity, when applied as a compressive strain, distorts the material, while in tensile strain the elasticity may be overcome long before the material yields by absolute rupture.

16. *Deflection of Beams.*—Resuming the bent lever hypothesis, it will be seen that the effect of the weight at any given plane of cross section is a tendency to rotate that plane about a horizontal axis, perpendicular to the neutral axis. To a very small extent this rotation actually takes place, the amount of motion being limited by the elasticity of the material, or the degree to which the normal distances between two particles can be extended or shortened. The planes of cross section, therefore, cut each other at the neutral axis. The amount of curvature at any point will vary as the force applied, and that force is equal to the weight multiplied by the lever arm, or, more concisely, is equal to the moment of the weight.

Let $p\, l$ be a layer of a beam deflected by the weight W, and let x represent the distance of any point in it from l. Then the

FIG. VI.



angles $1\, p\, 2$, $2\, x'\, 3$, $3\, x''\, 4$, etc., will vary as the curvature of the beam between the points of tangency of $1\, P$ and $2\, x'$, of $2\, x'$ and $3\, x''$, of $3\, x''$ and $4\, x'''$, etc. This will become clear by referring to Fig. VI, where $P\, c\, x'$ represents the angle of rotation between the two contiguous surfaces made by a plane of cross section. Since, as a condition of tangency, $1\, p$ is perpendicular to $p\, c$, and $2\, x'$ perpendicular to $c\, x'$, the angle included by $1\, p$ and $2\, x'$ must always be equal to $p\, c\, x'$. Hence the angle included between two tangents will vary as the curvature, which varies as the moment of the weight. Again, with a given angle made by two tangents, the amount of divergence will vary as the length of the tangents, that is, the farther any two tangents are extended the more widely they will separate. But the length of a tangent for small deflections is equal to x, and the divergence between any two consecutive ones (denoted in Fig. VI by the spaces 1.2, 2.3, 3.4, etc.) is the differential deflection due to the curvature of the differential space $d\,x$. The deflexion $d\,D$ therefore will vary in the combined ratio of the angle, or $W\,x$, and the length of the tangent, *i. e.*, as $W x^2$. Finally, it will also vary as the length of $d\,x$, or as the number of particles separated or stretched by the force $W\,x$. Taking $m =$ an experimental constant, we deduce the equation

$$d\,D = m\,W x^2\,d\,x, \qquad (1)$$

$$\int d\,D = W\,m \int x^2\,dx, \qquad (2) \quad \text{and}$$

making $x = l$, we have $D = W\,m\,\frac{l^3}{3}$. This equation is true, however, only for very small deflections. But as small deflections are the only ones to be encountered practically, this will be found sufficiently near for practical purposes. The expression $W\,x$, which is the moment of the weight, is called the bending moment in treating of deflections.

17. When the beam is loaded uniformly the expression for the bending moment is altered. If the point x be taken as before, the bending force exerted at that point will be that due to the weight between x and the free end, and its moment, since it is uniformly distributed, is $\frac{W'\,x}{2}$. But obviously $W' = \frac{W\,x}{l}$ and hence the bending moment is $\frac{W\,x^2}{2\,l}$. Using this bending moment eq. (1) becomes

$$d\,D = \frac{m\,W x^3\,d\,x}{2\,l}, \qquad (3)$$

$$\int d\,D = \frac{W\,m}{2\,l} \int x^3\,d\,x, \qquad (4) \quad \text{and}$$

making $x = l$, we have

$$D = \tfrac{1}{8}\,W m\,l^3 \qquad (5)$$

When the beam is supported at both ends, and weighted in the middle, we may without error consider it as supported in the middle, and weighted at each end with one half the weight, in which case $x = \frac{l}{2}$ and equation (2) becomes

$$\int d\,D = \tfrac{1}{2}\,W\,m \int x^2\,d\,x = \frac{1}{48}\,W\,m\,l^3, \quad (6)$$

When the load is uniformly distributed over the whole length, then by referring to Sec. 7 it will be seen that the moment of weight, or bending moment, becomes $\frac{W\,x\,(l-x)}{2\,l}$. Substituting this for $W\,x$, in equation (1), we have

$$d\,D = \frac{m\,W\,x^2\,(l-x)\,d\,x}{2\,l} \qquad (6) \quad \text{and}$$

$$\int d\,D = \frac{m W}{2\,l} \int l\,x^2\,d\,x - \frac{m W}{2\,l} \int x^3\,d\,x \qquad (7)$$

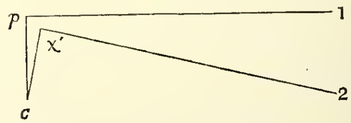
making $x = \frac{1}{2}\,l$ the expression, reduces to

$$D = \tfrac{5}{384}\,W\,m\,l^3 \qquad (8).$$

Since the deflection is usually expressed in inches, it is advisable in assigning numerical values to l, to reduce the measurements to inches, so that $W\,l$, or the bending moment, always express "inch pounds," and thus leave the unit of measurement for deflection in its simplest form.

18. Thus far we have treated of the deflection only, in its relation to the length and weight of the beam, and have practically assumed the cross section of the beam to be a fixed quantity. It is now necessary to treat of the relations of the bending moment and deflection to the cross section. In the foregoing equations the constant m is intended to be a factor expressing the deflection of a beam of a given length, and cross section under a given weight, while the whole equation gives the deflection of a beam of the same cross section, but of variable length. When the cross section is variable, m is no longer constant. But it still holds a determinable relation to the breadth, depth, and modulus of elasticity, which can be expressed in terms of those quantities. Assuming, then, that m represents the deflection of a beam of given length, but variable depth, its bending moment, $W\,l$, will vary inversely as the moment of resistance of the cross section, that is, as $\frac{1}{6}\,s\,b\,d^2$. By referring to Fig. VII it

FIG. VII.



will be seen that the angle formed at the neutral axis, by the elastic yielding of two contiguous particles, will vary directly as the bending moment, and inversely as the modulus of elasticity and the moment of resistance of the cross section. But the tension on the fiber $p\,x'$ remaining the same, the angle $p\ c\ x'$ will vary as $p\ c$, or as $\frac{1}{2}\ d$. Hence the depth again enters the expression, which now becomes $m = \frac{12}{E\ s\ b\ d^3}$. But since $\frac{1}{12}\ s\ b\ d^3$ is the moment of inertia of the cross section, we may write

$$m = \frac{1}{E\ I} \qquad (1)$$

E represents the modulus of elasticity with respect either to compression or extension. Taking the equations of the preceding section and substituting this value of m we obtain general expressions for loads variously distributed.

One end fixed and loaded at the other . . . $D = \frac{W\ l^3}{3\ E\ I}$ (2)

One end fixed and uniformly loaded . . $D = \frac{W\ l^3}{8\ E\ I}$ (3)

Both ends supported and loaded in the middle, $D = \frac{W\ l^3}{48\ E\ I}$ (4)

Both ends supported and uniformly loaded . $D = \frac{5\ W\ l^3}{384\ E\ I}$ (5)

(To be continued.)

IMPROVEMENTS IN COAL GETTING.

Compiled from "The Practical Mechanic's Journal."

That which has more than anything else characterized the mechanical progress of our own times, the steady and increasing substitution of machine agency for human and animal labor, has not until within a very few years made much advance in the underground workings of the coal-pit. Some grand ameliorations have been made, but much remains to be done; and so surely as the sewing machine was the true remedy for the miseries shadowed in the "Song of the Shirt," so must the effectual removal of the remaining ills of coal-pit labor (and of all other labor of analogous character) be found not so much in legislation as in the invention of effective methods for superseding it.

There have been other sufferings in coal-pit labor besides human ones. Horses are still largely employed in drawing the "corves" of coal from the headings to the bottom of the "drawing shaft." Without being sentimental, it may be boldly said that few animal existences can be more unnatural or unhappy than that of the coal-pit horse. But the increased depth of workings, the extension of underground "inclines," and many other circumstances, all converging towards the question of "cost," have sharpened the wits of coal viewers and engineers; and already vast progress has been made in the north of England and elsewhere, in substituting steam-power haulage underground, by means of the "endless rope system," for horse labor. Thus, not universally, but within certain limits, we see the curious succession of women and girls as beasts of burden giving way to boys and men, these to "ponies," and the last to steam. Several years have elapsed since the earliest attempts were made in Northumberland and Durham to apply mechanical haulage by one of the four systems under which it is at present worked, viz., by that of the single tail rope; and at least five years ago we ourselves witnessed, in the Hetton collieries, the degree of perfection to which that plan had even then been brought under the skillful superintendence of the viewer, Mr. J. Daglish, M. E.

The three other systems now all in use are, the endless chain system, the endless rope system—of which there are two modifications, not reckoning as a distinct system the endless chain plan of South Wales—and the system of single rope planes. In all of these the full corves are seized by the rope or chain at the required point, dropped off free, either by detachment or by cessation of the power at the required points, and the empty corves are brought back by power. A boy is needed to each train, and, as at Hetton, the highest ingenuity has been exhibited in devisal of the methods by which detachment from a constantly running rope is provided for. To the honor of mother wit be it recorded, that the beautifully simple and effective, though most original and ingenious, form of detaching hook in use at Hetton, was invented by one of these untaught boys who guided the trains of corves.

An admirable account of what has been done up to this time in the way of steam underground haulage, may be found in the "Transactions of the North of England Mining Institute," volume xvii, page 7, for August, 1868, with very carefully tabulated experiments as to the cost of such haulage work. According to circumstances, and chiefly to the rate of inclination of the trams, and the amount of coal hauled per twelve hours, it varies from a little above a penny per ton per mile, to nearly fourpence per ton per mile, of coal drawn. To these able reports we refer our readers, for our direct object here is not with the methods of leading the coal when "got" underground, but with improvements in the means of getting it.

The methods employed up to the present hour for "getting"—*i. e.*, for detaching coal from its bed, as generally practised in Great Britain—may be said to consist in "holing," under-cutting, or over cutting (generally comprised under the term hewing), the coal by hand labor; to a limited extent as yet, performing all these or at least two of them, by one form or other of "coal-cutting machinery;" wedging by hand to bring down the more or less isolated blocks of coal; and in many pits blasting the coal down or out of its seat, more or less by gunpowder or other explosive agents.

These methods are equally in use, whether the coal seams be worked by headings, by single or double "pillar and stall," or upon the "long wall" systems; and if we include in our view foreign collieries, more especially those of France, Belgium and Westphalia, where the seams are in general much more steeply inclined and disturbed than in Great Britain, these methods apply equally to all thick seams, however circumstanced. That blasting has been occasionally productive of accidents more or less serious, through the chance of the ignited fuze or the flash of the explosion igniting fire-damp, admits of no doubt. The absolute number of such accidents is small, and their proportion in relation to those traceable to all other causes is unquestionably small; but although that is so, it is the obvious dictate of prudence, if it be found practicable, to avoid blasting altogether, or in at least all "fiery seams." No wise manager can feel at ease in being obliged to sanction the continual use of blasting, where every charge, when exploded, may be, for ought that he or any one can predict to the contrary, in connection by an invisible and unknown gasiform fuze with the great explosive magazines of fire-damp that may be accumulated in the "goafs" or other parts of the workings. *Prima facie*, therefore, everything indicates the desirability, if possible, of getting rid of subterranean coal blasting, on the grounds of humanity and prudence.

But let us look at the matter a little more narrowly in the light of practical needs, etc. Drift-ways must be run into the coal, whether thick or thin, in order to reach and work the seam. These are often miles in length; unless in the exceptional cases of the very thickest seams, the headway required by the drift way, heading, or rolley way, which is from seven to nine feet, obliges more or less of the coal roof or coal seat, or of both, but generally of the first only, to be removed. This is very frequently composed of hard grit stone, or of "clunch," or other argillaceous or arenaceous material scarcely less hard. For the excavation of these primary works, in nearly every colliery, gunpowder, or some equivalent for it, is indispensable.

Again, there are certain coals which are themselves so hard that (as yet at least) no one has even suggested any way by which they can be dislodged from their beds but by means of blasting. Such is the case with much of the American anthracites, with some of those of the European Continent, and, above all, with the pure anthracite of the Kilkenny coal field in Ireland, which contains about 97 per cent of pure carbon, breaks with a vitreo-conchoidal fracture, and is almost as hard and difficult to dislodge as the rigid carboniferous limestone in which the seams occur, and to the "roof and seat" of which the coal is obstinately adherent. There are, therefore, cases in which coal mining must, to the end of the chapter, be pursued by means of blasting, so that we have our views as to the substitution of some other means of dislodgment thus limited at least.

We ought not here to omit to remark, before going further, that there is a wide field open for experminents with other explosive agents than gunpowder, with a view to discover whether some may not be found, and be so exploded that their dislocating effects may be employed, and yet that any fuze at all, or any flash capable of igniting fire-damp, shall be avoided or abolished. As to the fuze, there is no longer the slightest practical difficulty or objection on the ground of expense, complication, trouble, delay, etc., in employing galvanic or rather magneto-electric fuzes; and as the igniting points of these are plunged in the midst of the charge, ignition of fire-damp is no longer possible from the fuze; it becomes then limited to any flash producible by the charge; but may not this, too, be wholly got rid of?

Gun-cotton, nitro-glycerine, dynamite, nitro-picric powder, all give less flash, and one probably less capable of producing ignition in surrounding gasses, than that of gunpowder, all being fired as usual. But a discovery very recently made in Mr. Abel's laboratory at Woolwich, and since, to some extent, worked out into a practicable form, has shown that the explosive effect of gun-cotton in a given charge may be prodigiously increased in intensity by firing the charge, not by mere ignition at all, but by ignition and a blow or violent vibratory jar at the same instant. The same thing is no doubt true, and *a fortiori*, of nitro-glycerine. It is thus, at this crude stage of the inquiry, plain that we have the means of employing explosive agents greatly more potent and less capable of spreading ignition to fire-damp than gunpowder, and that we can still further reduce the charges of these more potent explosives by employing a suitable method of firing them. We may thus reasonably hope to attain for any given use charges sufficient, yet so small that the mere cooling contact of the coal or rock split by them shall prevent even a very slender probability of the flash, if any, spreading beyond the hole, or reaching any point to ignite fire-damp.

Experimental researches to decide the scope and value of such an inquiry appear to us quite worthy of our most advancing and scientific colliery engineers, with the aid and countenance of the Northern or of the South Wales Mining Institutes. Still there remains this incontrovertible proposition, so well insisted upon recently by Prof. Warrington Smythe, that where there must ever remain more or less room for doubt as to danger, and that danger such as may imperil many human lives, the judgment of every prudent man ought to be, "get rid of explosives in coal mining altogether, if it can be done." Professor Smythe did not affirm that it could be done, nor do we believe that it can, in all cases. Beyond question the ablest and most successful attempts in this direction, as well as in that at the same time for relieving the heavy labor of the coal hewer, have been those of the contrivers of coal-cutting machines. These, in several forms — mainly divisible into two generic classes, viz., those which *hew* in the proper sense of the word, *i. e.*, chop away the coal by blows with a sharp-ended implement like a pick, driven by power; and those which *slice*, or rather grind away the coal by one or many advancing tools, slowly driven by power, and moved like the cutting tools of a slotting machine—have now been more or less under trial for nearly seven years, and in a few places, both in South Wales and in the North of England, have been (one or other) brought into successful use; the power employed being compressed air, supplied by a fixed engine above or underground, and the air led along by pipes to the faces of the headings, or to the wall faces in work.

What may be done by compressed air as a motive power we need not enlarge upon; it has been abundantly shown at the great Mont Cenis tunnel, of which we have given several notices in this journal. Now, besides the advantages effectuated by this class of machines (we have no intention of going into any critique as to their relative merits), of relieving the coal hewer of the very heaviest part of his labor, viz,, the "under-cutting" of the coal, and the owner of by far the greater portion of the coal wasted and destroyed by being reduced to powder by the under-cutting by hand, and limiting the "hewer's" task to the cross cutting of the blocks and "getting down," by whatever means, the masses of detached coal; there are these further advantages—that the "under-cutting" can be effected much more deeply in, from the "face," than is readily practicable with hand labor, and that when indispensable the coal bed may be "overcut," or freed from the roof, if need be, in the same manner—a thing nearly impossible with mere hand labor. It is, however, a very rare case indeed that any moderately heavy seam of "fat" or flaming coal, or any other but of the hardest anthracite, needs any over-cutting, and that, no matter at what inclination or dip of bed. It almost always occurs that if the coal be effectually under-cut, the mass, thus for several yards in length perhaps, and for a depth in, from the face, of from three to six feet, hanging in air free from its support below, only needs to be cross-cut or "holed," when it breaks off at the rear and from whatever slight attachment it may have had to the roof, and drops by its own weight, and then all that remains is to hew or part it into suitable-sized blocks, so as to load it into the "corves," and bring it to bank. This part of the work is done, partly by the blows of the pick, partly by the "hewer's bar," and in harder coal by driving in iron wedges.

Recently there have been some who have thought that wedging might be much more extensively used in coal mining; and that, in fact, by the application of a much more powerful form of machine-driven wedges, coal might be detached bodily from its bed without the use of blasting, without the use of coal-hewing machinery, or hewing in any form either for under-cutting or holing; and that, in fact, this one new class of tool, either the power-driven wedge, or, as its equivalent, the expansion of plungers by hydrodynamic pressure, should become almost the sole and sufficient resource of the collier. This is what we propose to submit here to some slight examination in the dispassionate light of the actualities of the problem sought to be solved.

Five mechanical arrangements for coal-splitting were recently brought before the Institution of Civil Engineers, three of them being principal, and the others only incidental to the discussion upon the original paper by Mr. S. P. Bidder, A.I. C E., "On Machines employed in Working and Breaking down Coal."

The machine of Mr. Bidder was described as consisting of a small hydraulic press of twelve tons power, to which was attached a pair of tension bars, bent in the form of a connecting-rod or hinge-strap. These were placed one over the other in the bore-hole, and between them, at the extreme end, there was a clearance box and two metal pressing blocks, between which was forced, by the action of the hydraulic press, a split wedge fifteen inches long, causing a lateral expansion of three inches. The ram was then withdrawn, and a second wedge was inserted between the two parts of the first wedge, and was forced up until sufficient expansion was obtained to break the coal. The operation could be repeated several times if found necessary. The whole apparatus would weigh about fifty pounds. The hydraulic press was in future to be made of steel, and the ram would be cored out. In practical working each gang of colliers would be provided with the tension bars and three wedges, while the presses would be under the charge of the men who at present occupied the position of firemen, so that no new class of labor would be introduced. Trials had been made both in the seven feet and the nine feet seams at Harecastle; and in the latter, with three wedges, about twelve tons of coal had been brought down in only three or four pieces. It was found that the press could be applied, and the blocks brought down, in less time than was consumed by firing and waiting for the smoke clearing.

The second described machine was by Mr. C. J. Chubb. He thought some more simple and practicable means of getting coal by mechanical power could be devised than the costly, but skilfully contrived, coal-cutting machines. His first idea was to apply wedges, acted upon by hydraulic force, but he was induced to abandon that system, owing to objections to the use of wedges, and to adopt instead an apparatus consisting of twelve plungers, set side by side in a steel bar, which plungers, when acted upon by water from a hydraulic pump, would separate the bar in which they were set from another bar, formed in the shape of a cover upon the plungers. The pressing apparatus was 25 inches long, and it was attached to a hydraulic pump by a tube two feet in length, so that it might be inserted into the coal to a depth of about 3 ft. 6 in. The apparatus, with the cover on, was $4\frac{5}{8}$ in. in diameter. When, by the action of the pump, the plungers had reached their limit of $2\frac{1}{4}$ in., and further expansion was needed, the plungers were readily brought back to their first position, by opening an escape cock for the water back into the partially vacuous close vessel out of which it had been pumped, when a liner could be inserted between the plunger and the cover; and this process could of course be repeated. In practice, however, it was found that the first expansion of $2\frac{1}{4}$ in. was more than sufficient. It was stated that the collective area of the plungers was 24 square inches, and as the pump could exert a pressure of twelve tons on the square inch, a total pressure of 288 tons could be brought to bear on the coal.

This apparatus had been tried in the South Wales district, where the coal was of the most varied description. It was observed that, by the present system of blasting, it occupied on an average two men ten hours to break down and fill into trams four to five tons of coal, of which twenty per cent was "small," and the remainder much shattered. On the other hand, with this apparatus two men could readily break down twenty tons in an hour, which could be filled, when loosened, at the rate of ten tons per man per day, the whole of the coal so obtained consisting of large solid pieces. Again, by the present system, in order to break down 500 tons of coal a day, from a "four-foot" seam, a "face" of 600 yards was required, whether as "pillar and stall," or as "long work;" whereas with this apparatus the same quantity could be worked from 300 yards of "face." In this way there would be less space requiring to be ventilated, the working operations could be concentrated, and facilities would be afforded for effecting economy in other respects. We may remark, in passing, that but very little stress can be laid upon these statistics. The amount of coal got per man per shift, or day, can scarcely be thus crudely stated with any certainty at all, and must vary enormously with circumstances; and while it seems here underrated, we must say the possible performance of the hydraulic coal-splitter seems both to want confirmation by actual trial, and in the absence of that to appear overrated.

The third contrivance was that of Mr. Grafton Jones, of Blaina Iron Works, Newport, Monmouth, and is also a hydraulic coal-splitter, differing from the former mainly in this—that Mr. Chubb's consists of a central tubular stem, carrying a long row of short plunger plugs along the length of its two opposite sides, like the suckers upon the tentacles of a cuttle-fish, which, being inserted into a 4 in. diameter, or thereabouts, jumper or auger hole, the plungers, by pumping in water, are forced out in opposite directions, and in direct contact with the coal. Mr. Chubb's is essentially the same in principle; but one range of plungers is suppressed, and the remaining range of these, in place of being forced out directly against the coal, is forced out against a sort of hollow, trough-shaped cast iron "liner," the interior of which fits the faces of the plungers, while the exterior fits the inside of the auger hole in the coal.

In the course of discussion it was incidentally mentioned that Mr. Joseph Bramah, the inventor of the hydraulic press, had proposed its use for coal-splitting; the form which he suggested having been simply that of an extremely strong bag of reduplicated leather, made waterproof. This in its flaccid state was inserted into the flat-shaped hole prepared for it in the coal, and water was then forced in until the distension of the bag caused the fracture of the coal in the direction of least resistance. The two other splitting methods brought before the institution we need but briefly allude to, as one of these merely placed on record an old device of one of the members for splitting rock or coal, etc., by means of a conical screw of steel, screwed into a split cylindrical wrought iron nut of considerable length, inserted into the bore hole; while the other was but a suggestion for diminishing the mechanical disadvantage of the oblique action of Mr. Bidder's wedges, by means which the talented suggester himself would probably, on more mature consideration, abandon.

Now, we must make bold to say that we entertain the most entire want of confidence in every one of these contrivances, as machines ever likely to be brought into practical use in coal mining; and we apprehend that every coal viewer or mining engineer, who possesses some actual experience in coal working, must come to the same conclusion. The proposition, in fact, common to all three contrivances is really this, that by means of large holes, four to six inches diameter, of a few feet in depth, bored somehow into the coal, in directions more or less parallel with the plane of the seam, and more or less diagonal to the working face, and by the insertion and use therein of these hydraulic driven wedges or plungers, it is practicable (in the working sense of that word), without any previous other work or preparation, to drive out the coal bodily, while still gripped firmly between its seat and the roof, and cause it to separate and fall in dislocated masses.

We shall not deny the possibility of doing this in some seams and in some cases, with nearly level beds of great thickness, and of just the best quality of coal for its successful application; but we do entirely disbelieve the practicability of so working the vast majority of coal seams in this or in any other country. Coal, whether thick or thin, deposited in water-saturated strata, to whose cavities, rugosities, and bendings it has been moulded beneath enormous pressure for ages in action, is everywhere obstinately gripped between roof and seat. When the seam is enormously thick, and most suitable in respect to hardness and softness and splitability (if we may coin such a word), it is barely possible that more or less of the coal might be thus forced out of its place, leaving, however, almost certainly in every case, more or less of it adherent to the roof and to the floor. But if the seam be but moderately thick (say four feet or under), if the coal be soft and friable, or if it be very hard and difficult to fracture; if the roof or the floor, or both, be of hard material; if either, or both, be uneven, and pitted at the "coal parting" with them—or if the coal join on direct to the floor or roof, or both, without any thin parting seam of vegetable charcoal, shale, or other very fissile material—then we feel pretty certain that such attempt to drag or push the coal out of its place, as it were by the neck, must end in complete discomfiture, so far as rapid and economical working are concerned, assuming that the physical possibility be conceded.

It comes, then, to this, that if we are to split coal out in large blocks, with small waste by dust and powdered coal and slacks, we must free it first either above or below. We can then split it out, no doubt, but *cui bono?* what will be the use of wedging from behind to split out masses of coal which, when once properly undermined, will rapidly fall by their own weight, and then detached from roof, floor, and "heading" or "wall," leave nothing to be done but to break them up smaller, and to sizes to be loaded on to the "corves," all which must be done, as at present, by hands in any case? This is the case with all moderately thick coal beds, even though they be perfectly flat and level. It is much more the case with highly inclined beds, like those of Belgium and Westphalia, which are worked on the long wall system from the under side, and along "the strike" of the beds, and from which the blocks of coal, once under or over cut, fall of their own accord, often but too readily and suddenly.

But at this time of day there is probably not an intelligent and well-informed coal viewer in Great Britain (and few of these gentlemen are not both one and the other) but is prepared to admit that under-cutting by coal-hewing machinery of one sort or other is already an accomplished fact, and that time, and not a long time, alone is needed for the wide-spread introduction, as a matter of necessity, of coal-cutting machinery in all our great collieries. Well, then, we have the coal cheaply, economically as regards the waste coal, rapidly, and deeply under-cut; we cannot get rid of the coal hewer, he must be there to direct and to fashion to a portable shape the huge blocks got out; he is on the spot, therefore, to hole or cross-cut the huge blocks as these drop from the roof, and by their own weight part off from the face of coal behind; of what use, then, are the hydraulic wedges, or hydraulic plungers at all? They appear, under such conditions where alone they can be applicable, as simple surplusage, for no sane man, we presume, will imagine the physical possibility of forcing out *thin-seam* coal while still gripped both by roof and seat.

Thus much for splitting in general, and without reference to the mode of attempting it. Granted the necessity and the utility of the plan of working, we are very far from being satisfied that any one of the actual arrangements proposed even approaches the best possible, or even a workable form at all, for the purpose. We shall not go into details, but merely ask our professional coal viewing readers to ponder, in a practical mood, upon the facilities, or the contrary, for working straight and cylindrical holes of four to six inches diameter into various sorts and thicknesses of coal, and under the various and often complicated conditions in which the workings are circumstanced.

We ask whether these hydraulic wedges or presses, said to be 50 lb. weight each, but actually much nearer probably, if ever brought into a workable form, to 150 lb. weight each, and which *must* be carried about and *manually* handled, will prove convenient? Whether in friable and compressible coal much more of the power expended will not be absorbed in crushing the coal close by to powder, than in splitting off that more remote? and whether, in any one of the arrangements, but most of all in Mr. Bidder's wedges, a prodigious proportion of the power expended be not necessarily always wasted? and if power be wasted in any machine, time is wasted, and money is wasted.

If a choice is to be made between hydraulic driven wedges and hydraulic driven plungers, between the power of the hydraulic cylinder, which may be at once brought up to any pressure we like per square inch, applied direct to the coal, or to that awkwardly exalted by the interposition of wedges—we are compelled to give our voice in favor of the simple and direct application of the hydraulic plunger. All wedges driven by pressure act at enormous mechanical disadvantage as wedges; work is uselessly absorbed in friction, and the loss so produced is greater as the angle of the wedge is less. The very essence, it may be said, of the wedge as an efficient mechanical engine depends upon its being driven, *not by pressure, but by blows.* At each blow the friction of rest, constantly encountered by the wedge driven by pressure, is by the sudden jar converted into the friction of motion, the coefficient of which for the same surfaces and pressures is usually not much more than one-half of the former.

With the hydraulic cylinder applied direct, the real limit to the intensity of the pressure per square inch of pressing surface is that of the crushing coefficient of the coal. That makes the limit really a low one, and hence we will hazard the conjecture that were these coal-splitting contrivances likely to be called into actual use and practice, it would probably be found that perhaps the very best form in which hydraulic pressure could be applied at all, might prove to be in that of a modification of Joseph Bramah's original leathern water-bag. We have, now-a-days, materials and methods at hand for the construction of flexible, or partially flexible bags, into which water could be forced to all the pressure the coal would safely bear without crushing, such as were unknown in his day, and the structural problem presents few difficulties to the mechanical engineer. Upon the whole, and in conclusion, however, we continue to believe that it is the perfectionizing of coal-cutting machinery, and not to coal-splitting instruments, even though far better designed than any that we have been noticing, that we ought to look for attaining the unquestionably most important ends of saving risk by limiting the use of explosives, cheapening our coal-getting, and economizing our coal itself.

THE SPECTROSCOPE IN THE BESSEMER PROCESS.

Compiled from "Oestr. Zeitschrift," and adopted by Dr. Adolph Schmidt.

A number of years ago, when the Bessemer process first began to regularly produce materials valuable for trade and practical use, the difficulty of operating the process in such a manner as to obtain by it a metal of certain qualities as desired, was at once recognized. Besides other means conceived to obviate this difficulty, the use of the spectroscope also was then proposed and tried. It was expected that the changes in the appearance of the Bessemer flame, which take place towards the end of the process, and which are evidently due to chemical changes in the constitution of the metal, could be observed more accurately with the help of the spectroscope, and would thus make it possible to interrupt the process at the precise moment when the required degree of decarburization of the metal is obtained. It appears, however, that the results of these experiments were not satisfactory, from the facts that no detailed account of them has been published, and that the use of the spectroscope was not continued afterwards. About two years ago Professor Lielegg, of Gratz (Styria), took up this matter once more. By a series of experiments made by him at the Gratz Bessemer Steel Works, and published in 1867 in the reports of the Austrian Imperial Academy of Science (see "Dingler's Polyt. Journal," vol. 16, 1867, or "Berg. u. hm. Ztg.," 1867, No. 12 and No. 48), he discovered that under the most different circumstances, and with the most different pig irons, the Bessemer flame, when analyzed with the spectroscope shows, besides some varying and accidental lines produced by accessory constituents of the pig iron, a constant spectrum, consisting principally of several groups of black, green and blue lines. These lines are not to be seen at the very beginning of the process, they become visible in the second period only, when the temperature is more elevated and when the carbon begins to burn in a more lively manner. They remain visible and bright until, in the third period, they disappear one by one, simultaneously with the diminution of temperature caused by the lack of carbon in the metal. Professor Lielegg attributed this spectrum to the carbonic oxide gas, and designated the single lines, accordingly as C Oα, C O β, C Oγ, etc. He also found that the observation of the gradual disappearance of these lines has a practical value, because not only the moment of nearly complete decarburization (what is called "the change" by practical Bessemer men) can be determined more accurately, but also because different kinds of products may be obtained by making the interruption of the process dependent on the disappearance of the one or the other of the said lines of the spectrum. Thus the spectroscope came into regular use at the Gratz Bessemer Works. The results obtained at Neuberg (Styria) were, however, widely different from the above. The Neuberg works convert almost exclusively their own pig iron, which contains a considerable amount of manganese (three and a half per cent). This iron, in being converted by the Bessemer process, develops towards the end of the charge an opaque flame full of white smoke. This smoke is the thicker and the less transparent, the hotter and better the charge. By inserting a wrought iron pipe terminating in a receiver into the mouth of the converter towards the end of a charge, Professor Kupelwieser succeeded in obtaining a certain quantity of the solid matter which constituted this smoke. Mr. Schöffel, who analyzed it, found it composed of—

$Si\,O_3$ (Silicic acid)	34.86
Mn O (Protoxide of manganese)..	48.23
Fe O (Protoxide of iron)	16.29
	99.38

This smoke, which seems to be principally due to the presence of a considerable quantity of manganese volatilized at a very high temperature, as silicate or as protoxide, covers the Bessemer flame in hot and good charges to such a degree that the observation of the "change" becomes often extremely difficult, and it is proved by numerous experiments that, in this case, the spectroscope is of no use whatever, because the Bessemer spectrum then disappears completely. It has, besides, been noticed, that even in less hot and less smoky charges the spectrum is only visible intermittently, and often disappears before the iron is near the point of complete decarburization. In such a case spectroscopic observation is not only useless, but can lead into errors and mistakes.

However the spectroscope is still in regular use at Gratz, and Ternitz, in Austria, at Maximilianshütte, in Bavaria, at Marienhütte, in Saxony, and some other German Bessemer works which do not convert manganesic pig irons. But few, if any, of these works make their operations exclusively dependent on the spectral indications. It has been mentioned above that Professor Lielegg considers the Bessemer spectrum as identical with the spectrum of carbonic oxide. Professor Kupelweiser has expressed the same opinion. But Mr. Brunner, an Austrian metallurgist, has shown in No. 29 of the "Oestr. Zeitschr.," 1868, that this view is incorrect. According to Lielegg's own investigations, carbonic oxide gas when burnt with oxygen produces, under all circumstances, a continuous spectrum without any light or dark lines. Lielegg attempts to explain the different appearance of the Bessemer spectrum by the higher temperature. It is, however, not probable that the temperature of the Bessemer flame should be higher than that of a flame of carbonic oxide mixed with oxygen in Daniells' cock. Besides some of the characteristic lines of the Bessemer spectrum have been observed in the flame which is produced by the heating of the converter previous to the charge, when evidently a temperature as high as the one mentioned does not exist. Brunner has also discovered, that no part of the Bessemer spectrum is ever visible in the flame when the converter is heated for the first time after being relined, but that when the lining is not new the group of lines called C Oγ by Lielegg appear in the green part of the spectrum, which then contains also the lines of potassium, sodium and lithium. Mr. Brunner concludes, from these facts, that this spectrum is not to be identified with that of carbonic oxide, but must be produced by other constituents of the pig iron. In further considering that it would be very strange if iron and manganese would not produce a spectrum at so high a temperature, he thinks it probable that the Bessemer spectrum is principally produced by these elements. In fact several of Lielegg's pretended C O lines coincide with the black iron lines as defined by Prof. Kirchoff, of Heidelberg, who is one of the inventors of the spectrum analysis. Also Lielegg's line C Oη, which is violet blue, and situated so near the potassium line K β that both lines almost appear like one broad band, corresponds to the violet blue line, Mn_5, in the spectrum of manganese. Brunner besides suggests that Lielegg's group of lines, C O B and C Oj, might be identical with the yellowish and green manganese lines, Mn_1, Mn_2, Mn_3 and Mn_4.

This suggestion has been fully verified by more recent investigations made at Neuberg, in December, 1868. As these investigations have been made in a peculiar manner, specially adapted to compare two different spectra with the greatest accuracy, thus to ascertain some supposed total or partial identity, we here reproduce a short description of them, as published by Mr. A. v. Lichtenfels, in "Oestr. Zeitschr.," 1869, No. 2. The instrument used for the purpose is a pocket spectroscope of the manufacture of M. Hoffman in Paris. It consists of a tube six inches long and three-quarters of an inch in diameter, containing two prisms of flint glass, three prisms of crown glass and one lens. The latter is placed near one end of the tube, opposite the slit through which the rays of light enter. Its object is to make the rays parallel. A small telescope with four lenses is attached to the other end of this tube by means of a joint, by a slight motion of which any desired simple ray can be directed to the center of the field of view. A small glass prism, about five-sixteenths of an inch long, can at option be attached to the outside of the instrument, in front of the slit, covering only one-half of the latter, so as to allow of the simultaneous observation of two sources of light.

The light of the Bessemer flame passes through this glass prism by reflection into a part of the slit, through the other part of which enter the rays of another well known source of light, prepared for comparison. Thus the spectra of both sources of light appear side by side in the field of view of the telescope, and if an elementary body is equally present in both flames, the characteristic lines of that body must correspond exactly in both spectra, because the rays from both lights enter through the same slit and are refracted by the same prisms. This is the most reliable method of analysis by the spectroscope. The bodies destined for comparison are dissolved in alcohol, and the solution is poured with a spoon on a small dish of platinum, heated to a white heat, where it rapidly evaporates. It is very important to produce a flame as hot and bright as possible; for it would be difficult to see a weak spectrum at the side of another one as bright as that of the Bessemer flame.

To make a comparative experiment with the described instrument, at first the exterior glass prism has to be fixed to its place; after this the whole apparatus is set in such a position that the spectrum of the Bessemer flame can be seen through the tube; afterwards the platinum dish is placed in front of the object-glass and heated by a lamp, and finally the testing fluid is poured on the dish. Burning alcohol produces no other but the sodium line. The spectra of calcium (here chloride of calcium) and of copper (here nitrate of copper) were compared, but did not coincide with the Bessemer spectrum. But the spectrum of manganese (here chloride of manganese) corresponded perfectly. This spectrum, according to Simmler, consists of four broad green bands and one violet blue line situated quite near the potassium line of the same color. These green bands appear in the Bessemer spectrum as groups of green lines in an exactly corresponding position. Two of these groups of lines are very distinct; the two others which are situated nearer the blue field, are less bright. The optic power of the instrument was not sufficient to show the violet blue line distinctly in either of the two compared spectra. However the main part of the question is solved by these experiments, and it is proved that the Bessemer spectrum, in its principal and characteristic features, is not the spectrum of carbonic oxide, but that of manganese. As "the change" in the Bessemer process (that is the exterior signs which indicate the almost complete removal of the carbon from the metal) could only be made dependent on a spectrum produced by carbon or its compounds, the use of the spectroscope in this process has, in fact, no general and scientific foundation, but is based, wherever it is used with success, on the happy coincidence that the greater part of the manganese is removed from certain kinds of pig iron, when subjected to the pneumatic process, at about the same time as the main part of the carbon.

THE COMPOSITION OF CEMENTS.

From "The Building News."

The value of all cements must of necessity depend upon their composition. There are two distinct kinds of cement, with three distinct names—the calcareous, the hydraulic, and the plastic. The calcareous is everywhere known by the name of mortar, or that mixture of lime and sand commonly used for building. The hydraulic cements are those which will set under water, and the plastic cements are such as are applicable to plastering and stuccoing. Of lime there are many varieties, each of different merits. Vicat classified them as—1, rich limes; 2, poor limes; 3, limes slightly hydraulic; 4, hydraulic limes; 5, highly hydraulic limes. As there are different qualities of limes, so, of course, there must be of limestones. It has long been held, and universally proved, that the harder the ingredient the better the quality of the lime; that the best materials are those that dissolve the quickest, heat the most in slaking, and fall into the finest powder. It should be remembered, however, that each variety yields a lime of different quality—different in color, in its power of absorbing water, and varying in weight and in hardness. The rich limes are the purest oxides of calcium; they increase to double their bulk in the process of slaking, which is not the case with poor limes. Limestones containing from one to six per cent of foreign substances, such as silica, alumina, magnesia iron, etc., yield rich limes. The limestones may differ in appearance and in texture, yet if well calcined the lime will be the same. Soft chalk, hard ragstone, or marble, yield equally good lime, since the calcium they contain is the same mineral. Chalk, however, generally contains water irregularly distributed, and, not exhibiting the same change that marble or stone does, it is frequently unequally burned, and therefore slakes imperfectly. Dr. Higgins states that lime made from chalk absorbs the carbonic acid more rapidly than that made from stone, but the experience of others (the late Mr. Arthur Ashpitel notably) has not favored this conclusion. The mode of burning varies, but the general result is the same.

The resulting quicklime is lighter than the original stone, and differs essentially from it.

Poor limes are obtained from limestones which contain silica, magnesia, manganese, or metallic oxides. These foreign substances are present to the extent of from 15 to 30 per cent. They do not slake freely, and they are more liable to vitrify in burning. Oysters or cockle shells are found to vitrify more easily than limestone or chalk when suddenly heated, which is attributed to their saline matter, for when they have been long exposed to the weather they do not so easily vitrify. In proportion as limestone contains gypseous or argillaceous particles does it vitrify. Limestones containing much silica swell in setting, and may dislocate the masonry executed with them. If alumina be in excess the lime is apt to shrink and crack. If carbonate of magnesia be combined with carbonate of lime, as is the case in magnesian limestones, the original bulk is retained.

The mixture of hard, sharp particles—the harder and sharper the better—is necessary for various reasons. It facilitates the setting of the mortar, it renders it much harder and much more adhesive, and saves expense. Three kinds of sand are used in building purposes, but only two are employed for cements. River sand and pit sand only should be admitted into the composition of mortar, and the former is preferable, as it is free from clay. Pit sand should be well washed. Crushed quartz or flint, from its sharpness, has been considered to be the best material. Many builders use road-drifts, and have found it to be a fair substitute for sand, and withal economical. The Romans used burnt clay, in the form of pounded brick, very extensively; and the present method is to throw up clay mixed in any fuel in loose heaps and burn it slowly. Burnt clay was, indeed, largely used and advocated in France. Used as hydraulic mortars in large public works, it was found that the action of sea-water soon made them crumble to powder; and it was only in fresh water that the mortar stood well. Slag from furnaces and the scoriæ from the iron-works have also been used for sand; the latter not so frequently, on account of the iron found in it. Coal cinders have been used, but not with much success, and wood cinders, which, however, are found to be too alkaline for the purpose. These materials have a considerable effect in hastening the absorption of the moisture and facilitating the setting of the limes with which they are used. Puzzuolana—so called because originally found in the vicinity of Puzzuoli, near Naples—is a volcanic material. The following analyses of this material were given by Professor Ansted in his Cantor Lectures at the Society of Arts in 1865. We observe that they vary a trifle from the analyses given by the French writers:

	Puzzuolano.	Trass.
Silica	44.5	57.0
Alumina	15.0	12.0
Lime	8.0	2.6
Magnesia	4.7	1.0
Iron oxide	12.0	5.0
Potash	1.4	7.0
Soda	4.0	1.0
Water	9.2	9.6

The French writers consider that the mixture of common lime with these materials should be one of pounded lime to two and a half of puzzuolano, or to two of trass (or terrass), or one of lime to one of sand and one of puzzuolano. The matter, however, is largely one of economical calculation.

A good test of the purity of sand, and a most important one, is the homely practice of rubbing it between the hands If it be fit for use as mortar it will not soil the hands, and will be free from odor. Dr. Higgins, whose experiments on sands have made him an authority on the subject, has pointed out that mortar made with sand whose grains were about equal in size and globular, could not be so strong at any period of induration as that which is "mixed with as much fine sand as can easily be received into its interstices, in order that the lime may cement the grains by the greater number and extent of their contiguous surfaces." He also states that the sand that passes through a sieve *in washing* is finer than that which may be sifted through the same sieve when dry. Sand is never non-absorbent and imperishable, and therefore it is needful it should be pure when used for building purposes. The mediæval builders knew this, and hence the fine characters of their masonry.

The results of experiments made by Dr. Higgins, and detailed at some length in his work—now, we believe, out of print—are of considerable importance. Very briefly summarised, they may be thus stated: The interstitial spaces in sand are greatly lessened by wetting it; therefore he determined in using it for mortar to wet the sand completely. It was thus, too, that the air was easily expelled, and the lime equally diffused itself in the spaces by a little heating; but when, as he says, the water is added to a mixture of lime, powder, and sand, the air is entangled in the lime paste, and cannot, without a great deal of heating, be totally pressed out of the plastic mass. As an excess of water is injurious to mortar, this was found to be an excellent way to regulate the quantity used, "for the portion of lime water which fills the spaces in sand, and can be held by capillary attraction in a flat heap of it, is precisely the quantity which makes well-tempered mortar with one part of the best slaked lime and seven of the best sand." Other investigations showed that there were two kinds of grains, which Dr. Higgins denominated "sharp" sand and "round" sand. The conclusion of all his experiments goes to show that the quantity of lime which forms a mass somewhat plastic with sand and water, is the smallest quantity necessary for making the best mortar from such sand. Any further quantity of lime would be useless in the coarser sands and injurious in the finer. The necessary plasticity is induced by the smaller quantities of lime. The grains of fine sand are, he says, held asunder by the lime paste to a greater distance than they are by water, and "the reason why the finer sand requires more lime than the coarser and mixed sand is, that the spaces, which are more numerous in fine sand than in the coarse, are more augmented in the whole quantity of them by the particles of lime which intercede alike the coarse and fine grains."

We have already said that river sand, or "silt," is the best of all the kinds of sands used for building purposes. Pit sand is too fine, and not so sharp and gritty. Coarse and fine sands, then, should be mixed in order to obtain a good cement, since the finer grains fill the interstices of the larger, and so tend to consolidate the whole mass. The two ingredients should not be mixed before slaking, but the bulk of the water should be applied to the sand before it is mixed with the lime, Dr. Higgins' experiments teaching us that in this way the air is more easily expelled from the mass, and the mortar, therefore, is of a more endurable nature. This being so, the common practice of "duffing builders" in running up new houses to use sands without first washing them, indeed to use any kind of rubbish—sand mixed with organic matter—is discreditable. Surely, when the materials "found on the spot" are used, it is only common honesty to regard their quality, and to remove from them the deleterious matter with which they are charged.

It is important that all water used in making cements should, at least, be fresh. In any case it should not be polluted, stagnant water. All vegetable and organic matter should be as much excluded from the water as from the sand into which it is thrown. Ordinary water contains some acidulous gas, and therefore it has been recommended that no water should be used until the gas had been freed from it. After making several experiments, it was found by Dr. Higgins that lime water is far preferable to any other. On comparing specimens of mortar made with the best lime slaked with river water, and sand and water, and spread on tiles soaked in water, with other specimens made with the same proportions of lime, but *slaked with lime water*, and sand and lime water, and spread on tiles previously soaked in lime water, the latter at every stage of them were sensibly harder, and they adhered to the tiles better than the former. He adds that he had good reason to be persuaded that the extraordinary induration would proceed in time through the whole mass. Of course, it is not difficult to adopt this plan, since lime water is readily made by dissolving lime in large casks or tanks.

We have thus considered the main principles which affect the three ingredients of mortar—the lime, which is the cementitious medium, the sand, which is the matter to be combined, and the water, which is the combining element or agent. We have now to look—space compelling us to do it with the utmost brevity—at what preachers would call a few matters of application. The mortar must be durable; free, by its very compactness, from damps and atmospheric influences, and thus those much dreaded enemies, expansion and contraction, avoided.

These results are alone attainable by attending to the judicious combination of the various ingredients. Given pure materials, the best combination is proved to be one part of lime to five, six, or seven parts of sand, the latter varying, of course, with its nature. Pit sand requires more lime than sharp river sand or clear road drift. Coarse sand requires less lime than fine sand. Mortars made with common fresh lime, or with well burnt lime, but containing only one ounce (say) of lime in six or more of sand, have been found by some experimenters to be the best. An excess of lime may dispose the mortar to crack. According to Dr. Higgins, the highest proportion of lime to coarse Thames sand which may be used with safety depends on the circumstances in which the mortar is to be exposed. "No more than one part of lime to seven of coarse sand ought to be used in mortar which is to dry quickly, and less lime may not be used because it does not render the mass sufficiently plastic for building and incrustation." At the same time, if a larger proportion of lime be used, it should be only when the mortar cannot dry so quickly as when exposed to the sun. But hasty drying, it has been proved, frequently injures mortar. Then, again, if the lime be carelessly or imperfectly manufactured, the mortar cannot be other than imperfect. The lime should be screened about half an hour after the workmen have thrown the water upon it. When they slake lime mixed with sand or gravel in great heaps, without screening it—which is more frequently done than not—the mortar is not likely to be very good.

Lime very quickly imbibes the acidulous gas which has been expelled after burning if it be exposed to the air. Indeed, it cannot long preserve its virtues without confinement in air-tight vessels. Experiments have demonstrated that lime undergoes changes quickly; indeed, well burned chalk lime, kept in a dry room, will imbibe about a pound of acidulous gas in three weeks in the summer months, so that the longer it is kept, the worse it becomes. Workmen are apt to think it is sufficient to keep the lime dry, and store it in ricketty barrels. This is not the case. Lime may be greatly impoverished witout slaking sensibly. "The superficial parts of any parcel of lime. which fall into fragments or powder without being wetted, and merely by exposure to air, are quite unfit for mortar, since this does not happen until they have imbibed a great deal of acidulous gas." To prevent common cements being bad or imperfect, the lime should not be exposed a great while before it is converted into mortar. If this be not done, the lime will be reduced into a perishable kind of whiting; indeed, bad lime, bad mortar. Imperfectly burned and unprotected lime will only give a builder a poor article, and we are writing, of course, for those who do esteem a good common cement; and the quicker it is used, and the less exposed to the deteriorating influences of the atmosphere, the better material will it be.

ENGINEERING CHEMISTRY.

From "Engineering."

Chemistry, though the grandest of the sciences, and scarcely older than the present century, is probably second to none in the importance of its bearing on most branches of industry. But, notwithstanding this fact, the cultivation of chemistry as a science is, in this country, left entirely to the accidental interest of individuals; and it is almost exclusively in connection with medicine that the principles of chemistry are taught at any of our educational establishments. We have not, in this country, a single chair of general applied chemistry, and, with the exception of the professorship of metallurgy at the Royal School of Mines, there is no provision for teaching the special application of chemistry to any branch of industry. Though we have some able chemists, their functions are almost entirely educational, or they cultivate chemistry merely as amateurs, while the application of chemical knowledge and skill to industrial art is so far from being recognized as a profession, that, like engineering a century ago, it is a pursuit offering little definite prospect to those who might be disposed to follow it, and one that is taken up only under chance circumstances. We are, however, of opinion that there is not only room for, but a great need of, a class of competent chemists who would devote themselves to the practical applications of this science, and to whom manufacturers, engineers, and others, could safely apply for advice and assistance in cases involving the consideration of chemical principles and knowledge. Among engineers generally it is, in this country, very seldom that any great acquaintance with chemistry is to be met with; and even manufacturers, as a class, do not generally possess such an amount of chemical knowledge as would be desirable and necessary for the most efficient practice of their arts. Nor can it be expected that either engineers or manufacturers should in any case become so far masters of chemistry as to supercede the necessity for advice and assistance from those who have specially devoted themselves to the study of the science in its practical bearings. One of the most serious obstacles that stand in the way of the formation of any such class of professional chemists as we have referred to, is the absence of any criterion by which the competence of chemists may be judged of, and qualified men distinguished from the host of quacks and charlatans who dub themselves chemists. Consequently, the only thing by which the public can be guided, is the fact of a chemist holding some position or office, of which there are, in this country, hardly any which are not purely educational. Even those are very few compared with the want that exists for sound chemical teaching, and those few chiefly fall to the lot of chemists who devote their attention to abstract chemistry rather than to its practical application. We do not pretend to say how any wider criterion of chemical competence is to be established, but we do not hesitate to express the opinion that it is very much needed at the present time.

As regards more especially the application of chemical knowledge to engineering, there are unquestionably many branches of this profession in which it would be of the greatest value, and somewhere it is indispensable. Thus, for instance, in regard to the subject which is probably the greatest engineering problem of the time, viz , the disposal and utilization of town refuse, and the waste products of manufactories, etc., together with the maintenance of rivers and other accumulations of water in a proper condition, both as means of communication and sources of water supply for towns; it is impossible that it should be properly dealt with unless the chemical aspect of the subject is fully considered. Indeed the many serious evils arising from polluted rivers, sewage infection, and the waste material that would be of service in maintaining the fertility of land, are in a great measure to be ascribed to the one-sided views under which the present system of disposing of town refuse by water carriage was introduced, and to the disregard of those chemical principles which would have indicated the probable consequences of that system unless it were supplemented by measures for dealing thoroughly with the material to be removed, and not merely transforming its noxious influence from one locality to another. To this circumstance also must be ascribed the dead lock now existing in regard to sanitary regulations, and the improvement of the condition of towns by the construction of sewers.

The subject of artificial illumination and the questions as to the requisite purity and proper cost of illuminating gas constitute another field in which the services of the practical chemist may be of advantage to the engineer, and where the co-operation of engineers and chemists can alone be expected to lead to satisfactory results. Not in any way less important, or less capable of improvement by such united efforts of engineering and chemical skill, is the subject of economy of fuel. In the production of motive power, in the heating of dwellings, the various branches of metallurgic art, and in many other cases where fuel is employed, the quantity consumed is vastly in excess of that requisite for effecting the objects in view. Improvements in this direction would be a source not only of individual profit, but also of national advantage. We might extend the illustration of our views on this subject almost indefinitely, but we apprehend the possible profit of and urgent need for greater attention being paid by engineers to chemistry is very widely appreciated in the profession, and therefore we confine ourselves to mentioning the subject, in the hope that others may suggest a means of giving practical effect to our views, and make some effort towards carrying them out. The recognition of science by the State is as yet a principle too little acted upon in this country to warrant much hope of this idea being promoted from that direction; but our private societies, such as the Institution of Civil Engineers and the Society of Engineers, are sufficiently strong to take the initiative in this matter, and they might do good service by giving their support to some feasible plan for bringing chemistry more within the range of the engineer's notice, and making chemical knowledge more readily attainable by him than it is now.*

DEVELOPMENT OF CHINA.—The formation of a society is being actively promoted in Belgium with a view to the introduction of railroads and telegraphs in China, and the development of its mineral wealth. The project is favorably viewed by King Leopold, who has traveled in China.

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* These are timely considerations for America as well as for England, although the amount of sound chemical knowledge and practice in the arts would appear to approximate to the demand more nearly here than abroad. Our excellent schools are gradually supplying the want mentioned above, but they should be better endowed. The best thing governments and rich men can do is to give money to scientific schools.—ED. *Van Nostrand's Magazine.*

THE BESSEMER PROCESS IN THE MANUFACTURE OF COPPER.

By Franz Kupelwieser, Professor at Leoben, (Austria).

Translated from Oester. Zeitschrift.

No metallurgical process using exclusively atmospheric air as oxidizing agent, is able to produce a quicker and more energetic oxidation than the pneumatic or Bessemer process. It, therefore, must appear strange that this process has not yet been used in any other metallurgical manufacture than in that of iron and steel, although oxidation plays such an important part in the manufacture of other metals, that their separation from each other and their purification from noxious ingredients can in many instances not be effected without it. The reason why the pneumatic process has not before been used in the manufacture of other metals may be the following: The expenses for machinery necessary to make such experiments are considered to be very high. It is feared that a great loss of metal will result from the pneumatic treatment of most of these metals. It is expected that experiments of this kind would have to be made on a large scale, and consequently with a risk of considerable quantities of metal, because it has been experienced in the treatment of iron, that the Bessemer process does not work to advantage when applied to small quantities.

In considering, however, that the melting-points of most of the other metals and of their sulphides, when subjected to oxidizing processes, do not rise to such an extent as that of pig iron does in being converted into steel or soft iron, but that the products of such processes generally melt as easily as the original substances or compounds, it appears more than probable that the heat produced by the combustion of the matters to be oxidized, will be sufficient not only to replace the heat lost by radiation, but also to keep the final products in a fluid state even then, when the process has been carried on with smaller quantities. For small quantities of metal, small vessels only and less powerful blowing apparatus are required, and the absolute losses of metal caused by unsuccessful experiments, are less to be feared.

To further encourage proprietors of metallurgical works to undertake such experiments, I publish the result of a successful trial of this kind, as communicated to me by the Russian mining engineer, Mr. Jossa.

This trial was made in 1868, at the smelting works of Wotkinsk, in the Ural Mountains (Russia), with coarse metal of the following composition:

Copper	31.54
Iron	39.41
Sulphur	25.29
Calcium	1.26
Slag	0.95
	98.45

Charges of 40 pud=1,450 lb. avoirdupois of this metal were made in a small English Bessemer converter. This converter had been constructed originally for trials with pig iron, and had a capacity of 100 to 120 pud of iron. It was, therefore, too large for the mentioned quantity of copper metal. An abundant quantity and pressure of blast was furnished by the existing blowing engine, and the conversion was lively and rapid. It was intended in these first trials only to concentrate the metal, and not to produce black copper. To see how long the blowing was to be continued to advantage, samples of the slag were taken at different stages of the process. They were analyzed afterwards and were found to be composed of:

	No. 1.	No. 2.	No. 3.
Silicic acid	34.46	29.46	27.20
Alumina	4.73	3.13	2.26
Lime	3.06	2.53	2.00
Magnesia	0.33	0.28	0.28
Sesquioxide of iron	55.26	57.24	58.55
Peroxide of copper	2.13	8.46	8.53
Sulphur	0.11	1.68	1.77
	100.08	102.78	100.59
Containing metallic copper	1.70	6.75	6.81

The product of the operations was concentrated metal, composed as follows:

Copper	78.90
Iron	0.94
Sulphur	16.63
Calcium	1.04
Slag	2.44
	99.95

From these notes, as communicated to me, the following inferences may be made. The coarse metal used is to be considered as one of the purest ever made, not containing any antimony, nor arsenic, lead, nickel, &c. The only object of the oxidizing operation was, therefore, the scorification of the iron, so as to obtain a concentrated metal with a higher percentage of copper. The last of the above analyses shows that this task has been fulfilled by the pneumatic process in a very complete and satisfactory manner. The iron in the metal has, in fact, been diminished to such an extent that the product, after being calcined, can be converted into a very pure black copper by a single melting process. It appears that when air is blown through melted copper metal, the oxygen does not affect the copper as long as a sufficient quantity of iron and sulphur is present. The iron is burnt to protoxide, which unites with the slag, and a considerable part of the sulphur is burnt to sulphurous acid, which escapes. I may add some remarks on the analysis No. 3 given above, which shows the composition of the slag obtained, together with the concentrated metal, at the end of the process. This slag is very nearly composed like a singulosilicate, and melts pretty easy, the greater part of its basic constituents being compounds of metals. According to Plattner's rules of estimation, its melting point would be about 2300 deg. Fahr. It is remarkable that the copper occurs in these slags as peroxide, as it is generally found to be present as protoxide in such kinds of slags.

As the slag No. 3 contains 1.77 per cent of sulphur which would combine with 6.34 per cent of copper, forming a protosulphuret, it seems probable that the greater part of the copper found in the slag, exists there in this combination, as small particles of metal, being mechanically mixed with the slag. Thus the copper really oxidized and scorified would be reduced to a very small percentage.

By means of the above analyses and of the given weight of the coarse metal subjected to the process, the weights of the products may be approximately calculated thus:

Weights in Pounds.

	Coarse metal.	Concentrated metal.	Slag.
Copper.........	413.2	342.0	71.2
Iron...........	516.2	4.2	512.0
Sulphur........	331.3	72.1	19.9
Calcium........	17.5	4.4	
Slag...........	32.2	10.6	
Oxygen, silica, &c.	....	....	525.6
	1,310.4	433.3	1,128.7

It is seen, from this calculation, that the amount of slag is very large when compared with the quantity of concentrated metal produced. As this slag contains a considerable amount of iron, its specific weight cannot be very much lower than that of the metal, and the separation of the latter will take place slowly. The products have, therefore, to be kept in a fluid state for some time at the close of the process, so as to avoid unnecessary losses of metal. Should the slag, however, contain a noticeable percentage of copper, it can be melted over again in the blast-furnace, as is generally done with the slags resulting from the ordinary concentrating process. A large amount of protoxide of iron being formed during a pneumatic charge made with coarse metal, a considerable quantity (306 lb.) of silica is required to scorify it. It might, therefore, prove advantageous to add a certain weight of silica to the charge to prevent a too rapid destruction of the converter-lining. As regards the quantity of blast required for the process, no direct data have been given to me. But this can easily be calculated from the amount of oxygen necessary for the oxidation of the different substances that were removed by the process from the original coarse metal. In neglecting the small quantities of calcium and copper oxidized,

512 lb. of iron were oxidized with	146.2 lb. oxygen.	
240 lb. of sulphur do	240.0 "	
Total oxygen............	386.0 lb., or	
	4,246 cub. ft. (Austrian),	
To which added	15,973 "	of nitrogen,
Gives us........	20,219 "	of air.

Consequently about 1,500 cub. ft. of atmospheric air are required for every 100 lb. of coarse metal treated. From this the duration of a charge may be estimated at nearly 20 minutes.

The advantage resulting from the use of the pneumatic process in the manufacture of copper is chiefly this, that it enables us to convert the coarse metal directly into a metal so perfectly concentrated that, after being calcined, a single smelting operation will work it into black copper. Thus one calcining and one smelting operation are entirely avoided and the corresponding time, fuel and labor are saved. Continued experiments will decide in regard to the point up to which the process has to be continued, to obtain slags as poor in copper as possible. This process is, however, advantageous only in the larger copper works, where the ores are melted in large reverberatory furnaces holding as much metal as is required for a Bessemer charge, so that the coarse metal produced in these furnaces can be run directly into the converter without being remelted.

It is, nevertheless, desirable that further trials be made to make useful, for the manufacture of copper or other metals, a process which achieves so great things in the metallurgy of steel and iron. S.

FIRE AND BILGE PUMPS IN SHIPS.

ON THE LOCATION OF INDEPENDENT STEAM FIRE AND BILGE PUMPS IN STEAMERS.

From a paper by CHAS. H. HASWELL, Civil and Marine Engineer, New York, read before the Institution of Naval Architects.

Of all the instruments and appendages connected with a marine steam engine, and the provident fitting of a steamer, the independent steam pump, or donkey, stands preeminent in importance; both on account of its general utility and its being, under many very probable and oft-occurring circumstances, indispensable to the safety of a vessel. The applications of this instrument extend from the ordinary operations of a bilge pump and a boiler feed pump, to those of a fire and a hold discharge pump.

When, therefore, the extended, and in many cases, the indispensable operations of this instrument are duly considered, it would seem to be imperative that it should be located where it can be most readily reached, and where it can be operated for the longest period without being submerged by water, enveloped in smoke, or cut off by fire.

It occurs, however, that as a rule of British and European practice, that it is located in the hold of steamers, immediately upon the lower engine room floor; this practice taken in connection with the insufficient capacity of the pump for the general purposes of fire and leaks, would seem to have arisen from the functions of the pump, as viewed by the constructors of the engines, being restricted solely to the operation of feeding and pumping out boilers. The cases in which the location of the pump in the manner referred to are objectionable, are as follows:

1. A leak occurring in the furnace or water bottom of a boiler, and the hot vapor arising therefrom precluding access to the pump, and the setting of it in operation, whereby the water escaping from the boiler, not being replaced by the operation of this pump, would soon expose the tubes or crown plates of the furnace to be burned, and the boiler rendered thereby unsafe for operation.

2. A leak in the hull of a steamer suddenly occurring from a collision with ice, another vessel, a pier or a sunken rock, or the disruption of the propeller shaft stuffing-box in a propeller, whereby the influx of water would be fully equal to the combined capacities of the pump and engines to discharge. The distance between the pump and the floor of the vessel, or the level of the water in the hold, would be so little, that any arrest of the pump from continuous operation, for adjustment or repair, would involve its submersion before it could be set in renewed operation.

3. A fire occurring upon the main deck of a steamer, whereby the smoke would be drawn into the engine and fire rooms by the draught of the furnaces of the boilers, and this pump rendered inutile by the impracticability of reaching it to set it in operation.

4. A vessel grounded or stranded upon a sand or soft bottom, and leaking; her pump, from the ingress of sand and mud into her hold, would require frequent clearance; the delays consequent upon which would cause the pump to be submerged before it could be freed and set in operation. The only defence that ever has been advanced for this violation of regard to the safety of a vessel, in locating this pump, where in many cases as here shown, it would necessarily be inoperative, is, that, in the event of the hold being flooded with water, the fires in the furnaces of a boiler would consequently be drowned, and that, the steam wherewith to operate this pump being obtained from the boilers, its functions would cease with the drowning of the fires. Admitting this position to be strictly tenable, it does not meet the conditions of this pump, being arrested in its operations by sand, mud, smoke or the escape of steam. The position advanced, however, is not one of general application, as in a majority of cases, and especially in this country, there is an independent boiler connected with this pump, which, when located upon the main or spar deck, and acting independently of the engine boiler, its functions would not be affected by the influx of water into the hold of a vessel.

The common plea, that a pump located in the hold of a steamer, below the water-line, will operate more effectively than if located upon the main deck, is only advanced by some engine drivers, whose conceptions of a steamer are restricted to the operations of the engines and their dependencies, or by some owners of steamers, who are disinclined to incur the cost of a removal of the pump to a proper location.

In this connection the capacity of this

pump, proportionate to the dimensions of the vessel, is worthy of consideration; and, as a further rule of practice, the capacity of this pump in British and European steamers is much inferior to that in use in this country. The general security of lines in British vessels, under the stringent requirements of Lloyd's rules, has not generally opened the subject of the propriety of using a steam pump for other purposes than those referred to, as confined to the operation of the boilers of a vessel; for, in many cases, this pump cannot be used to draw water from the bilge or hold of a vessel, and has not any fire hose connections beyond the immediate precincts of the engine room.

The capacity of this pump, proportionate to the vessel in this country, may be judged of from the following cases: A British steamer, now in this port, built upon the Clyde as late as 1867, and belonging to a leading company in the extent and character of its trade, presents the following cases: $l - \frac{3\,b}{5} \times b\,\frac{b}{2} = 3{,}230$ tons has but one independent pump, having a water cylinder of one gallon capacity, or a discharging capacity of 12,000 gallons per hour, or 3.7 gallons per ton per hour.

The new steamers of the Pacific Mail Steamship Company, built in this city in 1867, present the following cases:

$$\frac{l - 3\frac{b}{5} \times b\,\frac{b}{2}}{95} = 4{,}200 \text{ tons}$$

have four independent pumps, having water cylinders of $17\frac{1}{2}$ gallons capacity, or a discharging capacity of 136,500 gallons per hour, or 32.5 gallons per ton per hour.

In further support of the position assumed, I submit that there has occurred very many cases where steamers have foundered, burned or been wrecked in consequence of the location of their independent steam pumps in their holds. Three cases, and important ones so far as the loss of lives and property are concerned, can but be familiar to all. The Arctic, foundered at sea, 1854, had two independent pumps of a combined discharging capacity of 31,000 gallons per hour, and an attached boiler, all of which were located in her hold. When her bottom was perforated by collision with the sharp prow of an iron steamer, the influx of water was superior to the capacity to discharge it, and for the following causes:

1st. Her independent boiler could not be put in operation until steam was raised in it.

2d. Her floor being filled in solid, her bilge injections could not operate effectually until the water was fully two feet in depth, in consequence of the roll of the vessel.

3d. At the time sufficient water had flowed into the hold for the bilge injections to operate with their full capacity, the additional depression of the vessel occasioned by this influx of water had reduced the number of revolutions of the engines, and consequently their capacity to discharge the inflowing water, added to which, the water at that height washed the water bottoms and ash pits of the boilers, and reduced their capacity to furnish steam to operate the engines. Thus with a constant flow of water the capacity to discharge it was being rapidly lost,

It occurred, however, that there elapsed a period of four hours after the collision, before this vessel sunk, and as a computation made by me of her entire weight as a mass, less the actual displacement of every particle of her and her cargo, gave but a difference of 1,000 (one thousand) tons, it appears that the discharge of this weight of water, or 65,570 gallons per hour, would have left this vessel free of water, and enabled her, so far as that collision was concerned, to have reached a port of safety. Now, as the capacity of her bilge injections, at even the reduced number of revolutions of ten, would have been equal to 80,000 gallons of water per hour, it is manifest that the loss of this vessel at this time is directly attributable to the location of her independent pumps and their attached boiler.

The Austria, burned at sea in 1858, in consequence of the smoke from a fire upon the main deck pervading the engine room and suffocating the watch, and as a consequence precluding the operation of her pump as a fire engine. The Britannia, lately foundered at sea by the flow of water in her engine room, and the submerging of her independent pump.

The remedy I propose for this objectionable manner of the fitting of a steamer, is to require this pump to be located upon the main or tonnage deck, and that it have an independent boiler attached to it, located upon the main deck, or preferably upon the spar deck, in vessels having two or more decks; and that all passenger steamers be required to have this boiler ready for operation during the night, or during the prevalence of a fog.

RETARDING RAILWAY TRAINS.

From "Engineering."

It is a somewhat curious fact that, while during the past three years or so railway engineers on the continent have largely adopted the plan of retarding trains by means of counter-pressure exerted against the pistons of the locomotives, the subject has received practically little or no attention in this country. That the ordinary plan of retarding trains by the application of brake blocks to the wheels is at best but a very imperfect one, it is impossible to deny; and it appears to us to be well worthy of consideration whether it cannot, in many instances at all events, be replaced by a less crude system. On those lines, especially, which have long inclines down which it is not safe to run the trains without the application of some retarding power, a more perfect method of effecting that retardation than that at present in use appears to be particularly desirable. On such lines not only does the rapid wear of the brake blocks introduce an important item into the cost of working, but there is an absolute waste of power caused by the use of the brakes which it is most important should be avoided.

A theoretically perfect brake would be one which, while giving perfect command of the train, should act as a kind of reservoir of power, absorbing the energy or "work" stored in the moving train, when the latter has to be retarded, and giving it out again as required, when a start has to be made or the motion of the train accelerated. It is scarcely necessary that we should observe that these ends can never be fulfilled practically, even in the remotest degree, by any brake acting on the principle of effecting retardation by opposing frictional resistance. We say *practically*, because, as far as theoretical principles are concerned, the application of frictional resistance would cause the transformation of the energy absorbed into sensible heat, and this might *theoretically* be again converted into its equivalent number of foot-pounds of useful work; practically, however, as we have said, this could not, of course, be done. Practically, in fact, all work expended in overcoming such frictional resistance as is produced by brake blocks, is lost beyond all hope of recovery; and in searching after a more perfect method of retarding railway trains, those forms of apparatus in which friction alone is used as a retarding power must therefore be avoided. Our reasons for saying friction *alone* will appear presently.

Leaving, then, friction brakes out of the question, there are three principal methods of retarding trains, which have at various times occupied the attention of inventors. Thus, in the first place, it has been proposed that trains should be retarded by causing them—through the intervention of suitable gearing connected at pleasure with the wheels—to coil or compress springs, these springs being subsequently released, and caused to give out their stored-up power to the train when the latter had to be started. Some very wonderful patents have been taken out from brakes of this kind; but it is, we think, unnecessary that we should say more of these plans, as all engineers will at once see their impracticability. Next, we have the suggestions of those who propose to retard trains by causing them to pump air into a reservoir, the air thus compressed being in some cases employed to furnish a motive power for assisting in the starting of the train. We remember the designs of one inventor who, with a desperate disregard of the £ s. d. side of the question, proposed to fit a number of the carriages on each train with cylinders, pistons, connecting-rods, valve-gear, etc.; it being intended that when the train was to be stopped this machinery (the valve-gear being reversed) should be employed to pump air into a mammoth reservoir carried in a special carriage, and that when the train was to be started the compressed air should be admitted into the cylinders of the carriages again, and made to serve as a driving power as long as it would last. As an idea, this plan was, no doubt, all very nice; but we fear that its chances of ever getting beyond the ideal stage are exceedingly remote. Of the various plans which have been proposed for effecting the retardation of trains by expending their energy in effecting the compression of air, the most practical is probably that of Mr. De Bergue, which has been used on the Northern, the Eastern, and the Western railways of France, and also, we believe, on one of the Spanish lines. Mr. De Bergue's plan consists in reversing the engine when the train is to be retarded, and causing the pistons to pump air into a reservoir with which the locomotive is provided; this reservoir being fitted with a safety valve. To prevent dust from being drawn into the cylinders from the smokebox, the blast pipe is shut off from communication with the latter when the brake is in action, and air is admitted through a valve provided for the purpose. The results obtained with this brake on short inclines have, we understand, been very satisfactory; but we fear that for continued use on long inclines it would be unsuitable, as there would be danger of trouble arising from the heating of the pistons, packing, etc.; moreover the work expended in compressing the air is, in this instance, as much lost as if it had been employed in overcoming the frictional resistance opposed by brake blocks.

The third class of brakes of which we intend to speak here consists of those in which the counter-pressure of the steam against the pistons of the locomotive is employed as the retarding power. Of these the best are those of M. Le Chatelier, Herr von Landsee, and Herr Krauss, each of which possesses certain advantages of its own which entitle it to consideration, and, we may add, certain disadvantages. Herr Krauss's plan* consists of an arrangement by means of which the blast nozzle can be closed, and the steam admitted into the cylinders through the exhaust pipes, instead of in the ordinary way; the steam thus admitted being partly pumped back again into the boiler through the exhaust pipes, and partly discharged into the valve chests, and thence through a valve into the chimney. The slide valves, we should mention, are constructed so that they cannot be lifted from their places by the pressure of the steam on the under side. According to this plan the engine is not reversed when the retarding power is to be applied, but the course of the steam is merely changed in the manner we have just mentioned.

In order to point out more clearly the differences between this plan and those of M. Le Chatelier and Herr von Landsee, let us consider more minutely what goes on in the cylinder when Herr Krauss's brake is in action. For this purpose we shall confine our attention to one cylinder, and suppose the piston to be at the commencement of its forward stroke. In this case the hind end of the cylinder will be in communication with the valve chest, while the whole of the cylinder in front of the piston will be full of steam, being in communication with the boiler through the exhaust pipe. As the piston is forced forward by the motion of the engine and train, this steam will be pumped back again into the boiler, this action going on until the exhaust port closes, and compression begins—the compression continuing up to what, in the ordinary course of working, is the point of preadmission, when the front end of the cylinder being placed in communication with the valve chest, the compressed steam is discharged into the latter, from which a portion of it passes through the valve already mentioned, into the chimney. So far we have considered what goes on at the front end of the cylinder; let us now examine what occurs at the hind end during the forward stroke of the piston. During the first part of the stroke, the hind end of the cylinder being in communication with the valve chest, any steam that may be in the latter is expanded into the cylinder, and this action goes on until the piston arrives at what in the ordinary course of working would be the point of cut-off. At this point communication with the valve chest is closed, and the steam in the cylinder continues to expand until the hind end of the cylinder is placed in communication with the exhaust, when the steam rushes in and fills the space behind the piston, the supply being kept up until the end of the stroke. It will thus be seen that during the first portion of each stroke—or up to what under ordinary circumstances is the point of exhaust—the resistance to the motion of the piston consists of the full counter-pressure of the steam in front of it, assisted by a partial vacuum behind. During the subsequent portion of the stroke, however, the steam is, as we have shown, admitted behind the piston, and the resistance to the latter is then only that due to the difference between the pressure of this steam and that of the compressed steam in front of the piston. We have not yet had an opportunity of inspecting indicator diagrams taken from engines fitted with Herr Krauss's apparatus; but we should anticipate that the rise of pressure which will take place during the compression of the steam will in many instances be so great as to be objectionable. If this is the case, however, the objection might be readily overcome by fitting a small spring-loaded valve, opening outwards, to each cylinder cover, these valves being of course so loaded that they would not open until the ordinary working pressure of the steam had been considerably exceeded. It will be noticed from the description we have given that Herr Krauss's is not a "regenerative" brake, or in other words, the work done by the pistons in retarding the train is not stored up for subsequent use. In other respects we consider the arrangement a good one.

* See "Engineering," p. 475, 1868.

The steam-repression brake of Herr von Landsee in some respects resembles in its action that of Herr Krauss's; but the mode in which the results are obtained is different. Like Herr Krauss, Herr von Landsee does not reverse the engine, when the brake is to be applied; but he closes the exhaust pipe, places the link motion nearly or quite in mid-gear, and admits the steam against the piston for nearly the whole stroke by means of an auxiliary slide valve, worked by an eccentric which is set without any angular advance. The employment of an additional valve, eccentric, etc., for each cylinder appears to us to be an important objection to Herr von Landsee's plan, and we must confess that we cannot at present see what advantages he can gain by his system which will compensate for the additional complication. We may remark here that in both Herr Krauss's and Herr von Landsee's plans, the cylinders are lubricated by the steam in the same manner as during ordinary working, so that there is no danger of overheating, cutting, etc.

We now come to M. Le Chatelier's apparatus, which has, during the past three years, come into extensive use in France, more than five hundred locomotives being fitted with it on the Paris, Lyons and Mediterranean line alone. The apparatus has also been applied to a large number of engines on the Northern railway of Spain and other Continental lines. M. Le Chatelier's apparatus may be simply described as an arrangement for enabling a locomotive to be reversed whilst running without danger of damaging the cylinders, valve-faces, etc., by dust or grit drawn in through the exhaust pipe from the smokebox. As fitted to the engines on the Paris and Lyons railway the apparatus consists of a closed copper box divided into three compartments, two of these compartments being respectively connected with the steam and water spaces of the boiler by suitable pipes, while the third compartment is separated from the two others by a partition having formed in it ports covered by small slide valves. By means of these valves steam and water can be admitted in regulated quantities when required into the third compartment, from which the mixture is conducted by a pipe furnished with branches to the exhaust pipes from the two cylinders. When the engine is reversed, the mixture of water and steam is admitted to the exhaust pipes, a portion of this mixture escaping through the exhaust nozzle, and preventing the ingress of air from the smokebox, while the remainder is pumped by the action of the pistons into the boiler. Recent experiments made on the incline at Etampes, on the Paris and Orleans railway, by MM. Forquenot and Le Chatelier, have shown that the admission of water alone, from the boiler into the exhaust pipes, fully serves all the desired ends, without the admixture of steam. When the water is admitted to the exhaust passages in this way the sudden relief of pressure causes it to be diffused as a fine mist, a portion being vaporised and escaping as steam through the exhaust nozzle, whilst the remainder enters the cylinders, and not only lubricates them and the valve-faces, but is evaporated by the heat developed by the friction, and is pumped back as steam into the boiler. The experiments with the apparatus have, in fact, shown that when an incline is being descended, the apparatus being in use, the pressure in the boiler increases rapidly, while there is no heating of the piston packing or valve-faces, and, the pumping of air into the boiler being prevented, the action of the injectors is not interfered with. This latter is an important point now that these instruments are so generally used for feeding locomotive boilers; and to ensure it, care should always be taken in using M. Le Chatelier's apparatus that there is a small escape of steam from the exhaust nozzle.

The retarding power obtained by reversing an engine, may be diminished or increased by placing the valve motion nearer to or further from mid-gear, and to enable this adjustment, and also the reversal to be effected with ease and safety while the engine is running the locomotives on the Paris and Lyons railway, fitted with M. Le Chatelier's apparatus, have been also provided with screw reversing gear, similar to that which we illustrate on page 300 of our third volume. In any case, however, the retarding power which M. Le Chatelier's arrangement is capable of affording, is less than that given by the plans of Herr Krauss and Herr Landsee. This will be evident if we consider what goes on during a stroke of the piston when an engine is reversed; and let us suppose for example that, as before, the piston is just commencing its forward stroke. In this case, the engine being reversed, the hind end of the cylinder will for a short portion of the stroke (equal to the period of preadmission in ordinary working) be in communication with the valve chest, and steam will thus be admitted. After the steam port is closed, there will be a period of expansion lasting until the piston arrives at the point which, if the engine was not reversed, would correspond to the commencement of the exhaustion during the backward stroke of the piston. On this point being reached the hind end of the cylinder will be placed in communication with the exhaust pipe, and the mixture of steam and water will thus be admitted from the latter into the cylinder. This admission will continue up to the end of the stroke. During the early part of the return stroke, the communication between the hind end of the cylinder and the exhaust continues open, so that a portion of the vapor admitted is forced back into the exhaust pipe again; but on the piston reaching the point which corresponds in ordinary working to the commencement of the exhaustion during the forward stroke, the communication between the hind end of the cylinder and the exhaust is shut off, and the vapor contained in the cylinder is compressed by the piston. Finally, when the piston reaches the point corresponding to the cut-off of the steam during the forward stroke, when the engine is not reversed, the valve uncovers the steam port leading to the hind end of the cylinder, and the full pressure of the steam is admitted against the piston during the remainder of its stroke, the steam thus admitted, together with the vapor already in the cylinder, being eventually forced back again into the boiler.

Briefly stated, then, the difference between the action of M. Le Chatelier's arrangement and that of Herr Krauss is this—that in the former the steam is admitted against the piston during a period corresponding to that of the admission of steam behind the piston, if the latter was moving in the opposite direction, and the engine was not reversed; while, according to Herr Krauss's plan, the period of admission of the steam against the piston corresponds to the duration of the exhaustion in ordinary working. At slow speeds the difference in the retarding powers of the two plans is perhaps not so very great, but when the engine is running fast the power of M. Le Chatelier's system is considerably diminished as compared with Herr Krauss's, the comparatively slow opening of the steam ports by the slide valve preventing the full pressure from being maintained against the piston, in the former case, for anything like the theoretical distance.

The want of sufficient power is, we consider, the only real objection to M. Le Chatelier's system; and there are very many circumstances in which even this objection does not apply. According to experiments made by M. Guebhard, of the Eastern railway of France, a retarding power can be obtained by M. Le Chatelier's arrangement equal to about 40 per cent. of the full tractive power of the engine; and there are very many cases in which this amount of retarding power will prove amply sufficient. In one respect M. Le Chatelier's system has a decided advantage over Herr Krauss's or Herr von Landsee's, and that consists in its turning to useful account a portion of the work performed by the pistons. The water admitted into the cylinders takes up the heat generated by the friction of the pistons, etc., and, being converted into steam, carries this heat back into the boiler. At first sight this may appear a small matter, but the experiments made by M. Ricour, on the Northern railway of Spain, have shown that in some instances the heat thus carried back during the running of one kilometre with the apparatus in action is equal to that generated by the combustion of 2.2 kilogrammes of coal, or about $7\frac{5}{8}$ lb. per mile. M. Le Chatelier's apparatus may therefore lay fair claim to belonging to the class of "regenerative" brakes.

The present article has already run to such a length that we must leave untouched many points connected with the subject on which we have been writing, and must conclude by saying a few words concerning an objection that has been often raised against the employment of any of the plans we have described. This objection is that the employment of all "piston brakes," if we may be allowed the expression, throws injurious strain upon the working parts of the engines. This objection we believe to be entirely without foundation so long as the resistance opposed to the motion of the pistons is not so great as to cause slipping of the wheels. Slipping is no doubt injurious in many ways; but we believe that it is very nearly as injurious if caused by the application of brake blocks as if caused by opposing resistances to the pistons. In any case the strain which can be thrown upon the connecting rods, etc., is limited by the adhesion of the driving or coupled wheels, and we fail to see that these strains can do more injury to the various parts when tending to retard the motion of the engine than when employed for the opposite purpose.

ROADS.

In an article on this subject, in the "New Jersey Courier," Mr. E. Sherman Gould, C. E., after pointing out the importance of *good* highways as feeders to railways, gives the following results of experiments and practice in France, which, though not modern, are standard and timely:—

"According to a most instructive tract by Gen. Sir John F. Burgoyne on the maintenance of macadamised roads, there were in France in 1835 some 45,000 miles of high roads, over which the yearly draft of merchandise was effected at an expense of about ninety millions of dollars. The French engineers calculated that at least one-third of this amount or thirty millions of dollars might be saved to the public by maintaining the roads in the best possible condition, and that not only at no additional cost, but with a positive reduction of the then annual expense of the maintenance. Now the French engineers are not subject to slips in their calculations, and it therefore becomes a most profitable study to investigate the means by which they proposed to accomplish this astonishing result. Briefly, they consisted first in putting the roads in perfect order, and then keeping them so. The system previously pursued had been to use the roads with few or no repairs up to the last moment it was possible to drag a vehicle over them, and then rebuild them entirely, preserving all the elements, such as bad drainage and bad foundations, which had already hastened their destruction. To accomplish the improved state of things, every attention was paid to the formation of the road-bed, and it was then subjected to a most minute and unremitting surveillance by an organized corps; every inequality of surface was filled up as soon as it occurred, and all waste matter was regularly removed, preferably as dust, with brooms in dry weather, but sometimes also as mud, in wet weather, by hoes and hand-scrapers, the horse-scraper being abolished, as battering the smooth surface. It was found that by this system of constant patching and sweeping, an immense saving of material was effected, since no more was put down than was absolutely required.

As an example of how far these calculations were verified, Gen. Burgoyne instances the case of the post road between the towns of Tours and Caen, a length of about 150 miles, which in 1836 was announced in an official report as being in so bad a state, that without a special credit of ten thousand dollars and a great additional provision of materials, there was danger that it would become impassable. In January, 1837, its reconstruction was commenced. In August, 1838, it was reported to be in a very good and constantly improving state. In 1834 the mail had always required five horses, and in one year eleven were lost by overwork. In 1837 four to five horses were required. In 1838 the number of horses was reduced to three. In 1841 only two were required of middling quality, and none were lost from over-work. In 1839 a lighter class of conveyances than that formerly employed was introduced, carrying nine passengers, *drawn by one horse at between seven and eight miles an hour.* The expenses of maintenance in 1837 were for materials $2,900; labor $2,500; total $5,400. In 1841 they were for materials $810; for labor $2,200; total $3,010. It will be thus seen that while the expense for labor remained nearly the same, the cost for materials diminished more than two-thirds.

The improved roads of France are all, or nearly all, macadamised. Their width varies according to their tonnage. The portion devoted to vehicles is never less than sixteen (16) feet. Ditches are dug on each side, and when necessary the road-bed is underdrained. The surface is slightly rounded, and but slightly, for it is important that vehicles should be able to stand upright on any part of it, so as to discourage the tendency to seek the center only, and produce a more even wear. As far as possible, the grades are kept between the limits at which water will run, and at which a vehicle will stand without running down hill by its own weight; when practicable not less than the former nor greater than the latter. The road-bed being properly prepared, it is covered with about six inches of broken stones, of such a size as to pass freely through a ring $2\frac{1}{2}$ inches in diameter, the stone being very carefully selected, chiefly with regard to its *toughness*, basalts and granites being the most esteemed. It is then heavily rolled, with rollers ranging from two to five tons in weight, the operation being repeated until the surface is compressed into a smooth, solid crust, gravel being slightly sprinkled over the road while in process of rolling. The road being thus brought to the highest degree of hardness and smoothness, *is never suffered to deteriorate.* This is the secret at once of its great carrying efficiency, and the economy of its repairs. The same reduction of shock and friction which enables a team to draw a heavy load swiftly over the surface, diminishes in a rapidly increasing proportion, its wear and tear. On the other hand, the incessant patching of the road wherever the uniformity of the surface is in the slightest degree impaired, reduces to a minimum the interference with rapid traveling, the amount of damage sustained at any given moment by the road and the quantity of material used in its maintenance, for the rough spots are always few and small, the little hollows formed in the road are never left to gain ground by wear and water, and not a pound of material is wasted.

Such are the leading principles which govern road-making abroad, and such we cannot but think the results to which our efforts in this country should tend. It is not, of course, to be hoped that, unaided as we are by government interference, we can attain to this degree of success in our roads, but we may rest assured that the nearer we approach to the path which the experience of older countries indicates, the nearer we will attain to the desiderata of a *maximum efficiency and a minimum expense.*

RIVERSIDE CONSTRUCTION.

From a paper by Mr. Rowland Plumbe, A.R.I.B.A., read before the Architectural Association.

The author said that he would confine his remarks principally to the description of a riverside building which had lately been erected, and to which his special attention had been directed. The building was of the warehouse description, of a great height, and designed for the storage of heavy goods, the floors being constructed to sustain five cwt. per superficial foot. Not only was there a frontage to the river, but the return wall, for a distance of about 150 ft., formed the side of a dock, part being built over and part forming a wharf wall. Large and lofty cellarage was required under the whole, the floor line of which was to be nearly 12 ft. under the highest water level. The tide rose and fell against the whole length of the front and side walls to a height of from 10 ft. to 13 ft. The special requirements under such cases are, first, to secure a thoroughly good foundation, and, secondly, to prevent the water from entering the cellars. In describing the means of obtaining these results, the author confined his attention to such measures as he had either seen taken or recommended by practical men, or had himself directed to be carried out, avoiding all recommendations found in books as being of less value than a simple description of the means used in a certain case with great success.

River Wall.—The first question to be determined in building the river wall is, whether to construct a dam or to build the work as the tide recedes. Wherever the tides will allow of the construction of buildings without a dam, the question is practically settled by the much smaller cost entailed, and the shorter time required for the execution of the work. Assuming, then, that the work is to be constructed without a dam (*i. e.*, by tide work), the water must be pumped out of the trenches immediately the excavations are lower than the mud bank of the river. A convenient place must be found for the engine, which should be of from eight to twelve horse power, and the pump should be capable of throwing out about 1,200 gallons per minute. The position of the engine will depend to a great extent on the position chosen for the sump, which should be placed as centrally as possible. The pump and engine being ready for working, the first excavation made will be for this sump, which is a well or receiver for all the water to be raised from the trenches, than which it should be sunk a few feet deeper. The trenches are then taken down to the requisite depth in lengths of from 15 ft. to 20 ft.; drain pipes of suitable diameter (say 6 in.) are laid along the trench, and when the water has been pumped out the concrete is filled in in layers to the required depth, suspending operations, of course, at each rise of the tide. The next sections can then be excavated on either side. The ends of the pipes laid along the bottoms of the trenches are now opened, to get rid of the water which has accumulated in them. As additional sections of the trenches are excavated, other lengths of pipes are connected with the former ones, the concrete is filled in, and the whole length of the foundations is easily and efficiently drained. It is important that the sump-hole should be excavated outside the trench. It should always be carefully filled up with fine Portland cement concrete when done with. The sides of the excavations will have to be close planked on each side, and carefully shored, and it is important that the sheeting should be left in the excavation when the concrete is filled in, the sides of the trenches not being sufficiently firm to hold the concrete until it has set, especially when disturbed by the drawing out of the planking. A necessary precaution in filling in and ramming is to protect the footings of the wall with concrete, instead of filling in with ordinary material, which is liable to be washed away by the scour of the river. As a rule it will be necessary to excavate until the sharp clean ballast is reached, and in any case it would be prudent to go as low as the bed of the river at its deepest part opposite the site of the building. Some architects advocate the forming of a foundation on a staging resting on piles driven to a great depth. Recent experience has, however, shown that this system is certainly not preferable to concreting, especially for heavy buildings, as the scour of the river will frequently so undermine the earth against the piles that all lateral support is taken away. Added to to this there are always chances of imperfectly driven piles and decaying timber rendering this form of foundation one of great risk. The concrete used should be a quick and hard-setting material. The author had found fresh burnt, finely ground Portland cement, especially made for hydraulic purposes, and mixed with clean river ballast in the proportion of one of the former to seven of the latter, to answer admirably. It should not be thrown from a greater height than necessary, nor should large quantities be thrown in at a time, as in that case the whole bed becomes jarred, and the process of setting is interfered with. Where practicable, a strong gang of men working alongside and throwing in the concrete with the spade as it is mixed, will obtain the strongest foundation. It frequently happens that the spring and return waters accumulate so fast that it is necessary to have the proportion of cement increased; the author had seen good work produced in such cases by having the concrete mixed dry, and again mixed with the water in the trenches as it was thrown in. It is always well to have a few sacks of cement ready to throw into the trenches when there is a danger of the cement being washed out of the ballast by the rapid ingress of the water.

The author next proceeded to describe a formula for ascertaining the thickness of a section of a river wall of given height to resist a given pressure of water; but any formulæ of this kind are of little value, because when the superincumbent walls are built, and the weight of the same and of the respective floors bearing upon them came on the top of the river wall, perfect stability would be obtained with a much less thickness than would otherwise be necessary. A less average thickness than six bricks would not adequately suffice to keep out the water and resist the impact of river craft. Even when of this thickness special precautions must be taken to guard against the first contingency. The wall should be gradually sloped up with footings from the concrete, and should have a batter on the river side of about one inch to a foot. The material and build of the wall are of the highest importance. In the wall referred to by the author, the hardest and closest textured stocks procurable were used, faced with Staffordshire blue bricks, not dressed, but of the ordinary building quality, built in Portland cement, and pointed with neat cement shortly after completion with an ironed joint, bevelled so as not to retain the water more than possible. In building the wall itself too much care cannot be taken in trying to make it as much like one mass as possible, and in seeing that every joint is thoroughly flushed up. Every course should be grouted, and the cement used with as little sand as possible, and never in more than equal proportions. In cases of this kind it is well not to trust to an ordinary workman to mix the cement. A banquer should be used, and the cement should be accurately measured, as also the sand, the latter (however clean in appearance) being carefully washed for use. No river wall is likely to keep back the water, in the construction of which imperfectly washed sand has been used, or in which a larger proportion of sand than cement has been employed. Roman cement should be carefully avoided in such cases, as its setting properties require more care than can be depended upon on the part of the ordinary run of bricklayers.

In order to render water-tight the wall constructed by the author, he had used a water-proof material built *in* its center, so as to be free from injury or decay. The wall was built in old English bond, and in its center a space of about $1\frac{1}{2}$ in. was kept between the stretching courses. This place was filled in with asphalte, and the heading courses were likewise bedded in asphalte. The great difficulty in the way of successfully applying asphalte in such a position is to keep the work sufficiently free from water until the asphhalte has cooled and set, for if the least steam or vapor is generated, it is liable to render the asphalte porous and spongy. A good water-resisting surface could be obtained by building up the center of the wall in the same manner, but using the cement quite neat, in conjunction with hard Staffordshire blue bricks. To ensure a waterproof wall the cement must really be used neat, and must be sufficiently air slaked as not to blow in the setting. The careful washing and cleansing of the bed of the work from the mud deposit after each tide has receded, must on no account be overlooked. Particularly must this deposit be removed from the racking back or toothed edges of that section of the wall which is above the other. Even a thin bed of mud would be sufficient to destroy the continuity of the cement work, and leakage would be the result. As an extra precaution it would be as well to point the inside face of the wall in neat cement, well raking out the joints and pointing with a flat trowelled joint for limewhiting. Although stock brickwork in cement is mostly used for river walls, certain non-porous stones and granite are sometimes used, but even with these materials there will always be a tendency for the water to find its way through the joints. The gault bricks, lately so largely used for sewer construction, are admirably adapted for river walls, provided they are kept thoroughly soaked in water before being used, for there is a danger of the cement not thoroughly taking to this kind of brick on account of its non-porous and fine texture.

The wall having been built in sections of from 15 ft. to 20 ft., the tidal water as it advances and recedes completely surrounds the whole wall at the same level during the whole time of its construction, and consequently it has at all times been free from the pressure of the tides. But in order that the inside banks may be cleared away and the building proceeded with, it will be necessary to shut out the water. Sufficient time must be given for the work to thoroughly set, and as a rule, it is better for a story or two of the superincumbent walls to be built over the river walls before shutting out the water, as the additional weight is a great help to stability. Six weeks or two months having been given from the building of the last section, and as much of the upper walls as possible having been built, the whole of the walls, every few feet apart, should be shored with whaling and wall pieces, and the wedges driven hand-tight, so as to resist any outward pressure towards the inside without forcing the wall outwards. This having been done, the openings should be carefully bricked up in neat cement, a tide valve for the exit of the spring and other water inserted, and the chief part of the river wall will have been completed. Although the tidal water comes up the face of the wall nearly to the level of the floor above the basement, it will be necessary to have a damp course slightly below the level of the basement floor. This can be of asphalte or of some of the glazed stoneware damp courses now used, provided that they are not perforated or so highly glazed as to prevent the cement from properly adhering to the joints and beds. A good material of this kind would effectually prevent the water from rising through the wall when under the greatest pressure of the highest tide.

As there is a liability of a greater amount of wear and tear at about the level of the highest water mark, and as it is highly desirable to have a good foundation for the walls supporting the upper floors, and a foundation of such a nature as to resist the dampness that would constantly be liable to arise from capillary attraction, it is usual to put a granite kerb at about this level. This should be in as long lengths as possible, joggle-jointed, the bed being at least 12 in. deep. For the protection of the wall from river craft, timber fender piles should be placed about 8 ft. apart. They are usually of fir, and should be Kyanised or Burnettised, or undergo some similar process. They should be 12 in. square, and so fixed to the wall as not to injure it in the event of great strains or sudden shocks being given to them. It is usual to bolt them through the wall, but where possible this mode of fixture should be avoided. A strong cast iron shoe, with a suitable flange, built into the wall to receive the bottom of the pile, and a head of a similar character, with a similar flange, both having bolt-holes, and both being secured to the piles with strong coach screws, will be found much safer. Of course, in wharf walls having no superstructure there will be no alternative but to bolt through the walls.

In designing river walls especial care should be taken to avoid projecting surfaces. Any projections or indents render the barges or other craft alongside liable to be caught by them as the tide rises, and held there un til the water rises over and sinks them, or until the wall itself was lifted or shaken. To prevent such occurrences the bolt-heads of the piles were frequently furnished with flat circular cast iron roses, with holes sunk for the bolt heads, but even this slight projection is objectionable. No projecting kerb should be put along the edge of a wharf wall, for it is sure to be lifted by the rising of the craft.

Wharf Walls.—A wharf wall with no superstructure upon it, and backed up by the bank will, if about six bricks thick, generally be found of sufficient strength. But where cellars or arched vaults are required, it is necessary to add to its strength, partly to resist the thrust of the arch, and partly to strengthen the wall beyond any fear of accident. The author had done this by building up piers at the back, and springing segmental arches upon them in a longitudinal direction, immediately over which the skewback of the vault was formed. In such instances it is always well to cover the backs of the arches with asphalte, laid on in two thicknesses, and with a slight fall towards the river, so that any water percolating through the pitching might find its way out down the ouside face of the wall.

Inland Walls.—On the land side, in works of this nature, provision has to be made against a permanent pressure of water which accumulates from the landsprings and other courses which, in such situations, always flowed towards the river. These being intercepted by the buildings alongside the river, it frequently happens that an outlet does not occur for some considerable distance, and where this is the case the danger of the water finding its way into the building is very great. As a rule, any system of drainage below high water mark had better be avoided, as depending upon receiving tanks, penstocks, tide valves, and other costly and uncertain arrangements. Any self-acting apparatus is likely to get out of order, and any machinery dependent on manual labor may at any time fail through neglect. In either case the result would be the complete flooding of the basement. For this reason all water should be kept entirely out of the basement, but for this no ordinary precautions are needed. More failures occur in the inland walls in respect of keeping out the water than in the river walls. The concrete, for such walls should be composed as before mentioned, or, if not, of Portland cement, at least of hydraulic lime. The walls should be, as a rule, at least four bricks thick, even though not required to carry the superstructure. They should be built in cement and of hard stocks, in the manner described for the river wall, and a water-resisting medium of the same nature, as before described, should be built up in the center of the wall. The wall on the outside should be pointed with a bevelled trowelled joint, or, better still, should be rendered in neat Portland cement. This last precaution will generally prove the cheapest and most efficacious in the long run, although somewhat expensive at first. A damp course, as before spoken of, will be most necessary, or the water will rise on the inside face of the wall, even from the concrete upwards, as, at extremely high tides, there may sometimes be at the top of the concrete a pressure of over 1,000 lb. per ft. of water. A lining of puddle, 12 in. thick, packed behind the wall as it rises from the foundations, in lieu of the ordinary filling in, will be most useful in keeping the water away from the wall. For some classes of goods it is desirable to have wooden floors in the cellars. When this is the case, the basement should be made lofty enough to allow of such a floor being put in and the requisite space for ventilation being provided under it.

The Floor.—Perhaps the floor is the most important feature for keeping out the water. In forming a judgment of the various steps to be taken to render the basement waterproof, it may be considered as a huge tank, which must be made entirely and at all points waterproof. Any waterproof coating on the inside (which could easily be got at) would, if put upon a sufficiently firm backing, effect the purpose of holding water. But to keep out water, the proper place to put the resisting material would be on the outside of the wall, the backing being inside. By the description of the construction of the side walls, it will be seen that this has been so far effected. In the building of the side walls the first precaution towards keeping the water from rising up through the floor will be to break the straight joint at the juncture of the floor and walls. Every alternate course of the brickwork below the floor level should be built out at least a quarter of a brick for a height of eight or nine courses. The brick piers for the supports of the floors should be similarly constructed. The first layer of the floor should be puddle, not less than 18 in. thick;

this being sure to drive the water to the walls, the value of the toothings will be manifest. The puddle should be well rammed into these toothings. The next layer should be formed of asphalte, a thin layer of concrete (say 4 in. thick) being laid over the puddle to receive it. The asphalte should be laid on in at least two thicknesses, and a row of hard bricks or gault tiles should be bedded against the walls—and especially the piers—until a good firm hold has been obtained of the brickwork. The asphalte should be carefully watched, and, if possible, left till a high tide has tried its resisting powers. Wherever the least defect occurs, a gault tile laid over it and another layer of asphalte laid over that will probably stop it. At all events, the asphalte must be laid on layer after layer until it has conquered the water, and it should also be carefully trowelled against the upright work of the piers and walls as high as the next layer, which is formed of Portland cement and fine ballast, in the proportions of one to five, and laid on 12 in. thick, the upper 3 in. being grouted to form a floor or to receive any floor that may be put on it. This sets like one solid mass of stone, and is most valuable in keeping the asphalte in its place.

The asphalte is not put on the surface because the author had found, both in upright and floor work, that, however efficacious it is to resist mere dampness, owing to its elastic nature, it parts from its backing and blows and cracks wherever there is even a slight pressure of water, and when once this takes place, it is powerless to resist the ingress of water. Where, however, it is confined between hard substances, such as those used for the flooring, or between a brick wall, it cannot move, and retains its water-resisting qualities. The interior of the walls should be coated with asphalte, and if not found sufficiently dry to admit of that operation, the joints should be raked out, the surface hacked, and a lining of two thicknesses of gault tiles bedded in neat Portland cement, finished with a trowelled surface, should be applied. This lining should go down to the edging of the gault tiles and asphalte, before mentioned, and the asphalte should be turned up against it. The cement should be the best obtainable, and it should be turned out of the bags and spread out for twenty-four hours before use to avoid the chance of blowing in the setting. If the tiles and cement are carefully applied by plasterers, the walls will be rendered waterproof. Mr. Plumbe, in conclusion, said the precautions he had pointed out were nearly all necessary for the successful execution of the description of work referred to, and he could recommend them as having practically tested them.

AIR-SURFACE CONDENSERS.

THEIR PRINCIPLES AND PROPORTIONS.

From "Engineering."

When a tube heated internally by steam or other means is exposed to the air, it loses heat in two ways, namely, by radiation and by convexion, the amount of heat lost by each of these means being subject to considerable variation, according to the temperature of the tube itself, the temperature of the air in contact with it, the temperature of surrounding objects, and other circumstances. At low temperatures the loss by radiation may be taken as sensibly proportionate to the difference between the temperatures of the emitting and receiving bodies; but at high temperatures, and with great differences of temperature, this law does not hold good. The loss of heat by convexion, or by contact of the air, does not vary directly as the difference of temperature between the heated body and the air, but becomes proportionately greater as that difference is increased. The laws which govern the cooling of heated bodies exposed to the air are, in fact, somewhat complex, and we shall not attempt to enter fully into their consideration here, but shall merely apply to the case under consideration the data which have been obtained by reliable experiments.

The most valuable researches on the cooling of heated bodies exposed to the air are those of Dulong, who has deduced from his experiments some excellent, though somewhat complicated, formulæ for calculating the loss of heat under different conditions. According to the experiments of Dulong, a horizontal pipe, 2 in. in diameter, containing steam at atmospheric pressure, and freely exposed to air at a temperature of about 57°, would be subject to a loss of heat sufficient to condense .34 lb. of steam of atmospheric pressure for each square foot of exposed surface per hour. If the pipe were filled with steam at a pressure of 100 lb. per sq. in., the temperature of the external air remaining the same, the loss of heat would be sufficient to condense about 0.8 lb. per square foot of surface per hour. These results agree very closely with those obtained in the course of ordinary practice by Messrs. Perkins, who have had very considerable experience in heating by steam pipes. Messrs. Perkins have found that in the case of pipes, charged with steam at a pressure of 100 lb. per sq. in., about 100 sq. ft. of exposed surface are requisite to condense per hour the steam produced by the evaporation of a cubic foot of water, whilst, when the steam in the pipes is of atmospheric pressure, about 150 square feet of surface are required to produce the same result. The amounts of steam condensed under the two circumstances were thus 0.625 lb. and 0.417 lb. per sq. ft. per hour, quantities which agree very fairly with those given by the researches of Dulong. These results, it must be borne in mind, are due to the combined losses by radiation and contact of air; but in the case of a surface condenser, consisting of tubes surrounded by steam and traversed by currents of air, the loss of heat by radiation would be vastly reduced, the cooling effect being almost entirely due to the contact of air alone. Under these circumstances the value of the cooling surface would be diminished to about one-half that of surface freely exposed to the air, and instead of each square foot being capable of condensing, per hour, about $\frac{1}{3}$ lb. of steam of atmospheric pressure, it would only be capable of condensing little more than half that quantity. On the other hand, the steam discharged into the condenser will, in all cases, have a temperature higher than that due to steam at atmospheric pressure, and this excess of temperature, combined with the rapid circulation of the air through the tubes, caused by a fan or other contrivance, will, to some extent, increase the efficiency of the condensing surface; and taking all these facts into consideration, we may, we think, fairly estimate the value of such tube surface, as about equal to that of freely exposed surface heated by steam at atmospheric pressure, each square foot being capable of condensing, say, $\frac{1}{3}$ lb. of steam per hour.

Taking this fact as our starting point, let us next ascertain the dimensions of an air-surface condenser, suitable for such an engine as that mentioned by our correspondent. It is proposed that the boiler of this engine should have 160 sq. ft. of heating surface, and this surface is estimated to be capable of evaporating 5 lb. of water per square foot per hour. The total evaporation would thus be $160 \times 5 = 800$ lb. of water per hour; and, supposing the whole of the steam produced to be used by the engine, the condenser would require to have $800 \times 3 = 2,400$ sq. ft. of surface. Again, if we suppose the condenser to be traversed by tubes $\frac{3}{4}$ in. in diameter inside, we should have almost exactly $\frac{1}{5}$th of a sq. ft. of cooling surface for each foot run of this tubing; and to obtain the 2,400 sq. ft. of surface, there would have to be 12,000 ft. run of tubing in all. If the tubes were 6 ft. long, 2,000 of them would thus be required, and these could probably be stowed within a casing about 4 ft. 6 in. in diameter; or if 3,000 tubes, 4 ft. long, were employed to make up the surface, they could be arranged within a casing having a diameter of about 5 ft. 6 in. In estimating these dimensions of the casing, we have supposed the distances between the tubes to be $\frac{1}{4}$ in. The weight of the condenser would be nearly, or quite, three tons.

Next, let us calculate the quantity of air which it would be necessary to supply to the condenser in order to carry off the heat abstracted by the steam; and in making this calculation we may fairly assume that the steam would be discharged into the condenser at a pressure of about 15 lb. per sq. in. above the atmosphere. The total heat of steam at this pressure is 1,190°, and to reduce a pound of such steam to water at a temperature of 212°, there would have to be abstracted $1,190-212 = 978$ pound-degrees, or units of heat. Multiplying this number by 800, the number of pounds of steam to be condensed per hour, we get $800 \times 978 = 782,400$ as the number of units of heat to be taken up per hour by the air passed through the condenser. Now, the specific heat of air, at the ordinary atmospheric pressure, is to that of water as 0.238 to 1, and a unit, or pound-degree, of heat will therefore raise a pound of air $\frac{1}{0.238} =$ 4.2°. If we assume that the air enters the condenser at a temperature of 60°, and leaves it at 120°, its temperature being thus raised 60°, the quantity of air required will be, according to the facts already stated, $= \frac{782,400 \times 4.2}{60} = 55,721.5$ lb. of air per hour. At a temperature of 63°, the weight of air is 0.0761 lb. per c. ft., and the above weight would thus correspond to $\frac{55,721.5}{0.0761} = 732,$-213 cubic feet per hour.

We now come to another point, namely, the power requisite to furnish this supply of air to the condenser. If we suppose the latter to contain 2,000$\frac{3}{4}$ in. tubes, 6 ft. long, these tubes will have a combined sectional area of 6.138 sq. ft., and the velocity at which they would be traversed by the air would be $\frac{732,213}{6.138 \times 60 \times 60} = 33.3$ ft. per second. To produce a flow of this velocity there would be required, according to the ordinary rules for calculating the flow of air, and supposing no resistances from friction, a difference of pressure at the two ends of the condenser equal to a head of about 0.00916 lb. per sq. in. Again, in the case of a $\frac{3}{4}$ in. pipe a foot long, there is required a difference of pressure of 0.000073 lb. per sq. in. at the two ends, in order to overcome the frictional resistances due to the transmission of one cubic foot of air per minute; and these resistances increase directly as the length of the pipe, and as the square of the quantity of air passed through it. In the condenser with 2,000 tubes, each tube would have to transmit $\frac{732,213}{2,000 \times 60} = 6.1017$, or, say, 6.1 cubic feet per minute, and, as the pipes are 6 ft. long, the difference of pressure at the two ends, to overcome the frictional resistances due to the transmission of this quantity, would be $6.1^2 \times 6 \times 0.000073 = 0.01629798$, or, say, 0.0163 lb. per sq, in. Adding this pressure to that formerly obtained as necessary to give the required velocity of flow, we get $0.0163 + 0.00916 = 0.02546$ lb. as the difference between the pressures at the two ends of the condenser tubes, requisite in order that they may transmit the necessary quantity of air.

This difference of pressure of 0.02546 lb. per sq. in. is the pressure against which the fan—or other blowing apparatus employed to supply air to the condenser—would have to deliver the air; and the net-work done by the fan will be the same as if the whole weight of air was raised to a height equal to that of a column of air of uniform density which would give the same pressure per sq. in. on its base as that against which the fan has to deliver. At the temperature of 62° the height of a column of air giving a pressure of 1 lb. per sq. in. on its base, is 1,892 ft., and the height corresponding to a pressure of 0.02546 lb. per sq. in. is thus $1,892 \times 0.02546 = 48.17032$, or, say, 48.2 ft. The total weight of air passed through the condenser per hour being 55,721.5 lb., the work to be done by the fan will amount to $\frac{55,721.5 \times 48.2}{60} = 44.762.9$ ft.-lb. per min. This, it must be remembered, is the net amount of work performed by the fan, as measured by the quantity of air delivered, and it will form, probably, not more than 60 per cent. of the power required to drive the fan, and consequently taken from the engine. Taking the effective duty of the fan as equal to 60 per cent. of the power applied to it, we should thus have $\frac{44,763 \times 100}{60} = 74,605$ ft.-lb. of work per minute, or 2.26 horse power absorbed in driving the fan, an amount probably equal to quite one-eighth of the total indicated power developed by the engine.

If, in place of 2,000 tubes 6 ft. long, 3,000 tubes 4 ft. long were used in the condenser, the power required to work the fan would no doubt be very considerably reduced, but it is unnecessary that we should do more than point out this fact here. Quite apart from the power absorbed in driving the fan the air-surface condenser is rendered unfit for application to a portable engine by reason of its cumbrousness, and there are really but very few situations in which it can be applied to engines of any class with advantage. So far as we are aware the only method of increasing the efficiency of condensers of this class is by moistening the air either by the injection of spray or other means, or by causing the cooling surface to be traversed by a thin film of water, as has been successfully done in some instances.

RESISTANCE OF ARMOR PLATES.

From a paper by Wm. Fairbairn, C. E., LL. D., F. R. S., read before the Institute of Naval Architects, March 18, 1869, and the ensuing discussion.

After a brief statement of the progress of marine iron constructions from 1836 to the present time, the paper stated that shortly after the appointment of the Iron-plate Committee, guns of different calibers were employed in the experiments, from the wall piece .87 in. bore and 5½ oz. of shot, to the 600-pounder breech-loader. The experiments commenced in May, 1861, with the wall piece and the smaller description of guns, and finished with the more powerful description of ordnance in 1864, when the committee was dissolved. During the continuance of the gun experiments, it was considered necessary that a similar class of experiments by statical pressure should be conducted on the same plates and targets, previously experimented upon in their resistance to impact by shot, the object being to determine the law of resistance of armor plates, and to establish formulæ for the guidance of the artillerist and engineer. Experiments were also made on shearing, tension, compression, &c., and the results obtained showed the density, tenacity, &c., of four different specimens—cut from the armor plate, one of which was of steel. The first series of experiments was instituted to ascertain the tenacity, elasticity and ductility of the plates from different makers, and to ascertain what changes and improvements were required to give the maximum power of resistance. The result of these experiments is given in the following table:

TABLE I.—*On Tensile Strain.*

Approximate thickness of plates in inches.	Mean density of plates.	Mean breaking strain per sq. inch in tons.	Mean elongation per unit of length.	Mean work *u*, for unity of length section done in causing rupture, in ft. lb.
$1\frac{1}{2}$	7.7471	24.453	.1769	4,844
2	7.7684	25.169	.3703	7,620
$2\frac{1}{2}$	7.7660	24.569	.2658	7,314
3	7.7666	25.031	.2689	7,538

The second series of experiments was upon compression, yielding the following results:

TABLE II.—*On Compression.*

Approximate thickness of plate in inches.	Mean ultimate pressure per sq. inch in tons.	Mean ultimate compression per unit of length.
$1\frac{1}{2}$	90.967	.513
2	90.967	.518
$2\frac{1}{2}$	90.967	.510
3	90.967	.511

The third and most important series of experiments was that on punching and shearing. It was supposed that the resistance of armor plates to the impact of shot was analogous to that produced by statical pressure. Under this supposition it was thought desirable to institute a series of experiments to ascertain to what extent the law was applicable to the resistance of iron plates by punching, in order to apply it to the more important experiments on impact. These experiments—made with a flat-ended punch—fully established the formula that the resistance of armor plates to a force tending to perforate them, varies as the diameter of the punch, multiplied by the thickness of the plate or the depth of penetration.

Another series of experiments with a round-ended punch was instituted by the Iron-plate Committee for the purpose of comparing the resistance of armor plates to flat-ended and round-ended projectiles, and tables were given to show that the statical resistance to punching was about the same whether the punch was round-ended or flat-ended. The following is the general table of comparison:

Description of Gun.	Weight of shot in lb.	Charge of powder in lb.	Velocity in feet per second.	Semi-diameter of shot.	Maximum thickness of perforation. By experiment.	Maximum thickness of perforation. By formula.	Error of formula.
Armstrong 6-pr......	6.25	0.75	1,141	1.22	1.286	1.406	$+\frac{1}{11}$
Armstrong 12-pr.....	11.56	1.50	1,155	1.46	1.803	1.769	$-\frac{1}{53}$
Armstrong 25-pr.....	24.81	3.13	1,169	1.84	2.350	2.337	$-\frac{1}{180}$
Armstrong 40-pr.....	40.00	5.00	1,166	2.34	2.820	2.663	$-\frac{1}{18}$
Armstrong 100-pr....	110.00	14.00	1,175	3.45	....	3.613	....
Smooth-bore 68-pr...	66.25	16.00	1,557	3.96	....	3.470	....

Mr. Scott Russell said, in regard to spherical shot, it was a well known law that if they took a plate of the semi-diameter of the spherical shot, it was just equal to the resistance of the shot. If he took the experimental column in Fig. 5, and took the semi-diameter of the shot as given in the fourth column, he saw, on the whole, no great deviation from this law; it seemed to be the simplest possible expression of it. 1.22 was the semi-diameter of the shot, and 1.28 was the maximum thickness of perforation. If he took the next figure, 1.46, then the other, 1.80 was greater; if he took the next, 1.84, then 2.35 was greater; and 2.34 was smaller, and 2.8 was again greater. These were elongated shot. As far as these experiments went, it would appear simply thus, that for the smaller diameter they might take the semi-diameter of the shot as the thickness of the plate; but as the diameter became larger it required a somewhat thicker plate to resist it. That was a summary of the conclusions given in the paper.

Mr. E. J. Reed said this paper had a value of a peculiar kind, because it placed before the Institution the experimental results obtained by Mr. Fairbairn in connection with the investigations of the Iron-plate Committee, which investigations had up to that time been a sealed book to the Institution and to the public. Several points required explanation. Among others the following: He did not quite understand what was meant by saying that the indentation was .37 with a round-ended punch, and .1 with a flat-ended. He presumed the undulation was measured to the innermost point of the punch, and if so, the comparison between the perforation with the flat-ended and round-ended punch would be very different to what the figures represent. Again, he could not persuade himself that the first formula written down was strictly accurate; that, in point of fact, the pressure was entirely proportionate to either the thickness of the plate or the indentation; because if they took the amount of force expended in punching a plate, there would be a very great variation in the amount of force exerted upon that punch during its passage through the plate. He thought there would be a great diminution of resistance per element of perforation in proportion as they approached the inside of the plate; in other words, when they got nearly through they finished the work much more easily than when they commenced it, and the formula that P raised twice r^2, left that quite out of consideration.

Mr. Bramwell said he gathered from the paper that the experiments in punching plates showed the resistance to be directly as the diameter multiplied into the thickness of the plate. The formula on which they agreed put the value of a plate to increase as the square of the thickness. If that were so, it would seem the resistance of the plate to impact was very considerably different in its law to the resistance of the plate to punching. With regard to the round-ended punch, it was stated in the reading of the paper that the work done to perforate a plate by the round-ended punch was greater than to perforate it by the flat-ended punch. In perforating armor plates by shot when there was the same amount of work residing in the shot, the shot with pointed ends did its work with more facility than the flat-ended shot; so that there did seem to be a very considerable contradiction between the different statements in the paper.

The New Turret Ship "Captain."—The armor-plated twin-screw turret ship Captain, built by Messrs. Laird Brothers, of Birkenhead, from the designs of Captain Coles, as the representative ship of his turret system, was recently launched with her engines on board and completely fitted. There are two separate pairs of double trunk engines, each pair driving a separate screw propeller 17 ft. in diameter. The collective force of the engines is 900 horse-power, nominal. The general construction of the hull of the Captain is similar to that of the large armor-clad ships built for her Majesty's navy. The turrets, two in number, and each carrying two 600-pounder 25 ton guns, project through circular openings in the upper deck. The part exposed to shot is covered with armor plates 10 in. thick about the ports, and for one-third the circumference, and with plates 9 in. thick for the remainder, while the lower part and all the gearing is protected by 8 in. armor on the side of the hull. The height of the center of metal of the guns is 12 ft. above the water line, which will admit of their being fought at sea in very heavy weather. The turrets are each 29 ft. external and 22 ft. 6 in. internal diameter. The low part below the armor sheaf is constructed in a cellular form, large openings being left for entrance and for passing in ammunition; these openings serve also to ventilate and light the lower decks. The turrets are supported by a strong girder on the lower deck, and revolve on a series of cast iron rollers, being kept in position by a solid wrought iron spindle securely fixed in the deck and carried down to the orlop deck; they are fitted with a complete system of hand-turning gear in addition to the steam gear. This steam gear is worked by a separate pair of engines for each turret placed on the orlop deck below the turret, where they are thoroughly protected from any chance of injury. The gear for starting these engines is so arranged that it may be worked either on the lower deck outside the turret, or by a system of rods led up through the central spindle to the sighting platform by the captain of the turret himself, who can thus take aim and direct the guns in the turret.—*The Engineer*.

Butchers' Steel Frogs.—The last report of the chief engineer of the Reading Railroad says: "The result of our experience with the Wm. Butcher cast steel reversible frogs has been very satisfactory. Of 73 put down, only one has been removed, on account of defects at one end, and none have been turned."

Another Proposed Ship Canal.—The Greek correspondent of the "London Times" writes: "The project of cutting a canal through the Isthmus of Corinth has been again discussed at Athens, and some people here think that circumstances render the execution of the enterprise perfectly practicable and ultimately useful, even should it not be immediately profitable. In a few months the work of M. de Lesseps at the canal of Suez will be so far completed that a number of powerful machines, admirably suited for work at the Isthmus of Corinth, may be obtained at a comparatively small cost. Skilled workmen will also be ready for employment, whose labor could be obtained at an expenditure trifling in comparison with what Greece would be called upon to pay under any other circumstances. No such favorable opportunity of constructing a canal through the Isthmus of Corinth is ever likely to recur. A glance at the map of the Mediterranean shows how important such a canal would be for the trade of all the ports of France, Italy and Austria with Smyrna, Constantinople and the Black Sea. The ports at both ends of the canal would not require any very great expenditure, and the canal, if made, could be kept open at very little cost. Its length would be three miles and three-quarters, but there is an elevated plain of limestone through which it must be carried that rises to an elevation of 250 ft. for a length of more than a mile. It is calculated that to construct a canal 150 ft. broad and 40 ft. deep would require the excavation of about 12,000,000 cubic yards of rock and clay. Whether the work would be profitable or not to a commercial company, there can be no doubt that it would be more useful to the Greek nation, and would not cost more money than a fleet of iron clads to drive the Ottoman fleet out of the Archipelago, for which the Hellenes are raising subscriptions."

EFFECTS OF COLD UPON IRON.

From "Engineering."

All railway experience in those countries of which the climate presents extreme ranges of temperature has shown that rails break far oftener in winter than in summer. It has been suggested that the chief reason is that the road-bed, being frozen in winter, affords no elasticity to the sleepers, the spring of the ballast being supposed to afford a high protective power. A theory advanced by Mr. Colburn in 1863 has gained some acceptance, viz., that all iron is charged, to a greater or less extent, within its pores, with moisture. It is well known that water may be forced, almost in spray, through the walls of a hydraulic press cylinder under great pressure, and all iron is found to be more or less porous when the attempt is made to retain highly compressed air within vessels constructed of that material. It is a question how far the great expansion of zinc, tin and lead, indeed, of all the more fusible metals when heated, is due merely and solely to their low cohesive resistance, or to the expansion of interstitial moisture acting against a comparatively small resistance. If moisture be present, as there is every reason to believe it is in all iron, its freezing will fully account for the failure of iron rails in extremely cold weather.

In 1867 Mr. C. P. Sandberg, Swedish Government Inspector for railway materials for the railways of his native country, made a most important series of experiments upon the strength of rails at different temperatures—ranging from 10° to 84° Fahrenheit. To make sure that the question of the comparative rigidity of supports did not affect the results, he made his trials upon the planed surface of a granite rock, and upon which were placed two bearing blocks of granite, 4 ft. apart, upon which the trial rails were laid. Each rail was tested with a falling weight, a 9 cwt. iron ball raised progressively to heights varying from 5 ft. to 11 ft. The following most important table of results fully explains itself, and shows how brittle were the rails in extreme cold weather as compared with summer heat:

CLASS OF RAIL.	Progressive number of Blows.	Height of Fall of the Ball in Feet.	Permanent Deflections.	Broke	Temp'ture. Deg. Fahrenheit.
			in.		
Aberdare rail No. 1, 21 ft. long	1	5	1	......	35
do	2	6	....	Broke	35
One half of the same rail	1	5	1	......	35
do	2	6	$1\frac{3}{4}$	......	35
do	3	7	$2\frac{3}{4}$	......	35
do	4	8	....	Broke	35
The other half of same rail	1	5	$\frac{7}{8}$	......	84
do	2	6	$1\frac{3}{4}$	......	84
do	3	7	$2\frac{3}{4}$	......	84
do	4	8	$4\frac{1}{4}$	......	84
Became twisted and could not be	5	9	$5\frac{1}{2}$	......	84
tested further	6	10	6	......	84
Aberdare rail No 2, 21 ft. long	1	5	$\frac{1}{2}$	......	35
do	2	6	....	Broke	35
One half of the same rail	1	5	$\frac{3}{4}$	......	35
do	2	6	$1\frac{3}{4}$	......	35
do	3	7	$2\frac{3}{4}$	......	35
do	4	8	....	Broke	35
The other half of same rail	1	5	$\frac{7}{8}$	......	84
do	2	6	$1\frac{3}{4}$	......	84
do	3	7	$2\frac{7}{8}$	......	84
do	4	8	4	......	84
do	5	9	$5\frac{1}{4}$	......	84
do	6	10	$6\frac{3}{4}$	......	84
do	7	11	....	Broke	84
Aberdare rail No. 3, 21 ft. long	1	5	$\frac{1}{2}$	......	35
do	2	6	1	......	35
do	3	7	....	Broke	35
One half of the same rail	1	5	$\frac{3}{4}$	......	35
do	2	6	....	Broke	35
The other half of same rail	1	5	$\frac{7}{8}$	......	84
do	2	6	$1\frac{7}{8}$	......	84
do	3	7	3	......	84
Became twisted and could not be	4	8	$4\frac{1}{8}$	......	84
properly tested further	5	9	$\frac{1}{2}$	......	84
Aberdare rail No. 4, 21 ft. long	1	5	....	Broke	35
The one half of same rail	1	5	....	Broke	35
The other half of same rail	1	5	$\frac{3}{4}$	......	84
do	2	6	$1\frac{3}{4}$	......	84
do	3	7	$2\frac{7}{8}$	......	84
do	4	8	$3\frac{7}{8}$	......	84
Became twisted and could not be	5	9	$4\frac{3}{4}$	......	84
tried further	6	10	$6\frac{3}{4}$	......	84
Aberdare rail No. 5, 21 ft.	1	5	$\frac{1}{2}$	......	35
do	2	6	1	......	35
do	3	7	$1\frac{1}{4}$	......	35
do	4	8	$2\frac{1}{2}$	......	35
do	5	9	$3\frac{3}{8}$	......	35
do	6	10	....	Broke	35
One half of the same rail	1	5	$\frac{3}{4}$	......	10
do	2	6	$1\frac{3}{4}$	......	10
do	3	7	....	Broke	10
The other half of same rail	1	5	1	......	84
do	2	6	2	......	84
do	3	7	3	......	84
do	4	8	$4\frac{1}{2}$	......	84
do	5	9	6	......	84
do	6	10	$7\frac{1}{2}$	......	84
do	7	11	....	Broke	84
Aberdare rail No. 6, 21 ft.	1	5	$\frac{3}{4}$	......	10
do	2	6	....	Broke	10
The one half of same rail	1	5	....	Broke	10
The other half of same rail	1	5	$\frac{3}{4}$	......	84
do	2	6	$1\frac{7}{8}$	......	84
do	3	7	$2\frac{7}{8}$	......	84
do	4	8	4	......	84
do	5	9	$5\frac{1}{2}$	......	84
do	6	10	$7\frac{1}{2}$	......	84
do	7	11	....	Broke	84
Aberdare rail No. 7, 21 ft.	1	5	....	Rroke	10
The one half of same rail	1	5	....	Broke	10
The other half of same rail	1	5	1	......	84
do	2	6	$1\frac{7}{8}$	......	84
do	3	7	3	......	84
The other half of same rail	4	8	$4\frac{1}{2}$	......	84
do	5	9	....	Broke	84
Creusot rail No. 1, 21 ft.	1	5	$\frac{1}{2}$	......	35
do	2	6	1	......	35
do	3	7	$1\frac{5}{8}$	......	35
do	4	8	....	Broke	35
The one half of same rail	1	5	$\frac{3}{4}$	......	10
do	2	6	$1\frac{7}{8}$	......	10
do	3	7	$2\frac{1}{2}$	......	10
do	4	8	....	Broke	10
The other half of same rail	1	5	$\frac{3}{4}$	......	84
do	2	6	$1\frac{3}{4}$	......	84
do	3	7	$2\frac{1}{2}$	......	84
do	4	8	$3\frac{1}{2}$	......	84
do	5	9	$4\frac{1}{2}$	......	84
do	6	10	....	Broke	84
Creusot rail No. 2, 21 ft.	1	5	$\frac{1}{2}$	......	35
do	2	6	1	......	35
do	3	7	....	Broke	35
One half of the same rail	1	5	$\frac{3}{4}$	......	10
do	2	6	....	Broke	10
The other half of same rail	1	5	1	......	84
do	2	6	$1\frac{1}{2}$	......	84
do	3	7	$2\frac{1}{2}$	......	84
do	4	8	4	......	84
do	5	9	....	Broke	84
Creusot rail No. 3, 21 ft	1	5	$\frac{1}{2}$	......	35
do	2	6	....	Broke	35
One half of the same rail	1	5	$\frac{3}{4}$	......	10
do	2	6	$1\frac{3}{4}$	......	10
do	3	7	....	Broke	10
The other half of same rail	1	5	$\frac{3}{4}$	......	84
do	2	6	$1\frac{1}{2}$	......	84
do	3	7	$2\frac{1}{2}$	......	84
do	4	8	$3\frac{1}{2}$	......	84
do	5	9	....	Broke	84
Greusot rail No. 4, 21 ft.	1	5	$\frac{1}{2}$	......	35
do	2	6	1	......	10
do	3	7	$1\frac{3}{8}$	......	10
do	4	8	$2\frac{3}{4}$	......	10
do	5	9	....	Broke	10
One half of the same rail	1	5	$\frac{3}{4}$	......	10
do	2	6	....	Broke	10
The other half of same rail	1	5	$\frac{3}{4}$	......	84
do	2	6	$1\frac{3}{4}$	......	84
do	3	7	$2\frac{3}{4}$	......	84
do	4	8	4	......	84
do	5	9	$4\frac{7}{8}$	......	84
do	6	10	....	Broke	84
Creusot rail No. 5, 21 ft.	1	5	$\frac{3}{8}$	......	35
do	2	6	1	......	35
do	3	7	$1\frac{3}{4}$	......	35
do	4	8	....	Broke	35
One half of the same rail	1	5	....	Broke	10
The other half of same rail	1	5	[illegible]	......	84
do	2	6	[illegible]	..	[illegible]
do	3	7	[illegible]		[illegible]
do	4	8	[illegible]	.....	[illegible]
do	5	9	....	Broke	[illegible]
Belgian rail No. 1, 21 ft.	1	4	....	Broke	10
One half of the same rail	1	4	$\frac{3}{4}$	......	10
do	2	5	....	Broke	10
The other half of same rail	1	4	1	......	84
do	2	5	$2\frac{1}{8}$	......	84
do	3	6	$3\frac{1}{2}$	......	84
do	4	7	....	Broke	84
Belgian rail No. 2, 21 ft.	1	4	....	Broke	10
One half of the same rail	1	4	....	Broke	10
The other half of same rail	1	4	$\frac{7}{8}$	......	84
do	2	5	2	......	84
do	3	6	$3\frac{1}{8}$	......	84
do	4	7	$4\frac{1}{2}$	......	84
do	5	8	....	Broke	84

THE MARTINI-HENRY RIFLE.

Fig. 1.

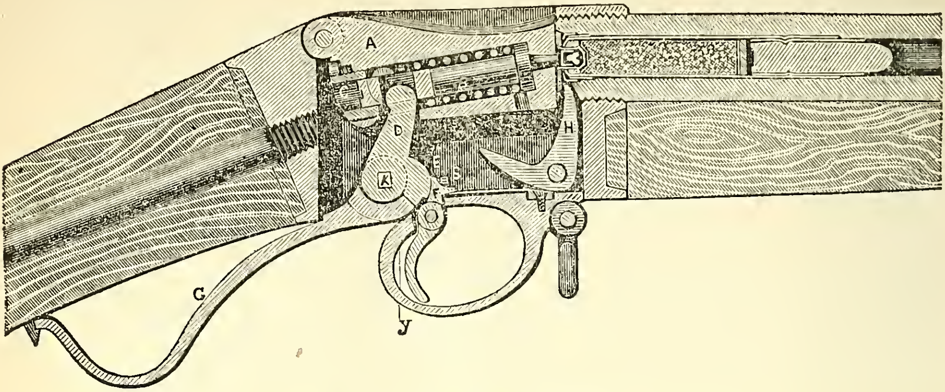


Fig. 2.

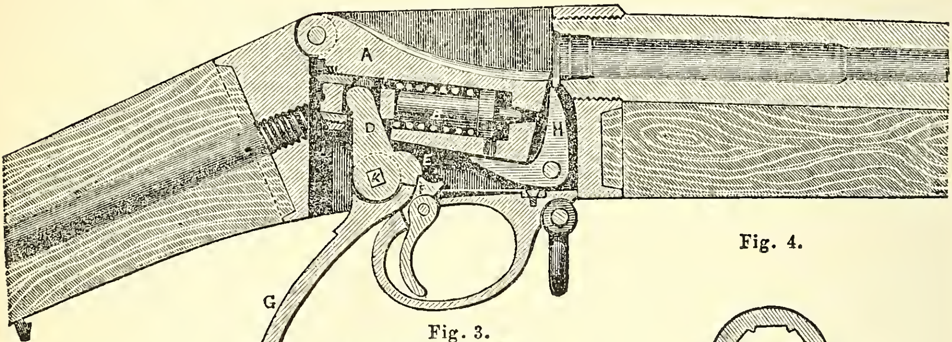


Fig. 3.

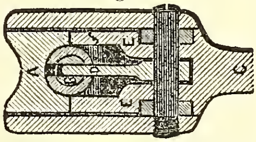
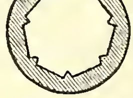


Fig. 4.



The question of the military arm of the future, which has been so largely discussed in England for some months, appears at last to be definitely settled by the adoption of a rifle bearing the above name. This weapon is the joint production of two inventors—Mr. Martini and Mr. Henry—the breech mechanism of the former and the rifling of the latter having been adopted by the Government. The progressive steps which have led to the final selection of this arm have been previously referred to. Nine breech-loaders were selected from more than a hundred which competed, and the final arm was selected from these. The arm has yet to be tested in practical use by the troops, a limited number of which will be first supplied with the new rifle. But we have no reason to apprehend that this trial will not lead to its final and general adoption in the English army; indeed, judging from the severe tests it has undergone at the hands of the Small Arms Committee, we should say there was no chance of failure on any point.

The breech mechanism, as adopted, we illustrate in our engraving, figs. 1 and 2, from which it will be seen that it is extremely simple in construction. Fig. 1 shows the breech closed with the striker forward, and fig 2, the breech open ready for loading. The breech block A works on a pin, and contains the striker B, surrounded with its main spring. This striker is confined in its chamber by the hollow screw C. The bottom of the breech block is slotted to allow the end of the tumbler D to engage with the striker. The tumbler is mounted on the axis K, which is squared at the point of contact with the tumbler, so that as the tumbler is raised or depressed the axis moves with it and so alters the position of an indicator outside the lock. The hand lever G, in its downward movement, serves to open the breech and draw back the striker. The tumbler moving with the lever engages itself on the nose F of the trigger. A further continued downward movement of the lever G acts against the inner face of the hollow screw C, and causes the breech block A to lower itself on its pin as a center. The upper part of the lever G is forked, and embraces the tumbler as shown at E E, fig. 3. As the lever is pressed down, the breech block is opened, and, as it moves, the tumbler is forced back, drawing back the striker, and compressing the main spring at the same time, till the nose F of the trigger engages with the tumbler rest. The object of the tumbler rest is to relieve the trigger from the whole weight of the tumbler and main spring. As the trigger is pressed, its first movement relieves the tumbler from its rest. The whole weight of the spring is now on the trigger, and a further pressure releases it. The working of the extractor is easily understood from a glance at the engraving; but at the same time it will be well to remark that the lower arm of the extractor H is so shaped that the first impact of the breech block with it serves to loosen the cartridge case in the chamber; then, as it further descends, the motion of the extractor is more rapid, and the case is ejected clear of the gun. Fig. 3 is a transverse section of the breech block mechanism through the plane $x\ y$, fig. 1.

In the early patterns of the Martini system an indicating pin was provided at the back of the breech block and in the upper part of the stock, which projected when the arm was cocked. This indicator was worked by the head of the striker, and as it was found to get out of order, another and more simple indicator was substituted. As mentioned above, this last improvement is fixed on the end of the tumbler axis, and therefore shows exactly the position of the tumbler. In order to obviate any danger that might arise through carrying the arm loaded and cocked, the committee added a safety bolt S, which engages with the trigger, and prevents it being moved. Other minor improvements have been made, such as lightening the cleaning rod, and modifying the shape and position of the sight.

The cartridge for this rifle is the invention of Mr. Henry, and, as it will be contained in a central-fire Boxer case, it is called the Boxer-Henry cartridge. It is 450 gauge, the bullet weighing 480 grains, and is composed of lead hardened with tin. A paper wrapper is placed round the bullet, the edges being returned into a slight cavity at its base. Pure beeswax is used for lubrication, and is placed between three discs made from jute cardboard. The charge consists of eighty-five grains of powder. This cartridge is shown in section in the barrel of the rifle at fig. 1.

Turning from the breech mechanism and the cartridge to the barrel of the new arm, we may observe that it is 35 in. in length, and is rifled upon Mr. Henry's principle, shown in section in fig 4. This is known as the polygonal system, and is seven-sided. Down each angle formed by the intersection of the planes of the polygon is a raised rib, which is tangential to the same imaginary circle as that to which the plane sides of the bore are tangential. This form of rifling leaves the bore more cylindrical than any other, except perhaps the Armstrong many-grooved system. In it what Mr. Henry terms a re-entering angle is formed, thus affording to the bullet a bearing at fourteen points instead of seven. The pitch of the rifling is one turn in 22 in., the caliber being 460 of an inch. The Henry barrel has proved itself singularly free from fouling, and the excellency of the rifling has fully maintained itself to the last. A rifle on this principle was fired 3,000 times without its accuracy being in the least degree impaired. With the cartridge above described, the Woolwich practice in the latest trials has habitually given the unparalleled result of lodging the bullets in a square of about $2\frac{1}{8}$ ft. at a range of 1,200 yards.—*Mechanics' Magazine.*

NEW RAILWAY BRIDGES—THE KEYSTONE BRIDGE CO.—The Newport and Cincinnati bridge, now in charge of Mr. Linville, President of the Keystone Bridge Co., has the greatest span of permanent railway bridge truss on this continent, viz., 420 ft. The same engineer is erecting an iron bridge over the Mississippi. at Keokuk, consisting of eight spans of 164 ft. 6 in., two spans of 250 ft., and a pivot span of 370 ft. This bridge is designed for railway and road way traffic, the width in the clear being 20 ft. It is proportioned to carry a rolling load of 3,000 lb. per foot with 6 as a factor of safety.

The Keystone Bridge Co. are erecting one of their patent pivot spans of iron, 360 ft. in length, at Kansas City, the remainder of the bridge being of wood, with wrought iron lower chords, from the designs of O. Chanute, chief engineer. The spans vary from 140 to 250 ft. The same company is erecting a double track iron bridge for the New Jersey R. R. and Trans. Co., at Newark, with two permanent spans of 96 and 115 ft., and a pivot span of 217 ft.

The great wooden bridge over the Susquehanna, at Columbia (to replace the one destroyed after the battle of Gettysburg), consists of 26 spans of 200 ft. each, one span of 150 ft. and two iron spans of 100 ft. each. This was designed by Mr. Linville, and erected by the same builders—some 6,000 ft. in length in all—between May and December, 1868. Numerous smaller iron bridges are building by the same company for the Pennsylvania, Fort Wayne and Chicago, Northern Central and other roads. Most of the iron bridges on the Pennsylvania Railway, and those on the Connecting Railway at Philadelphia, were designed by Mr. Linville. Several of them are large works, such as the iron span of 262½ ft. over the Schuylkill.

EXPERIENCE IN DESIGN.

From "Engineering."

Engineers are frequently called upon to design structures, the proper proportions of which cannot possibly be determined by any process of mathematical investigation, no matter how refined or laborious. Under such conditions a careful consideration of similar works already executed is absolutely imperative. The successes attained and the defects evinced in many of the works of our predecessors afford evidence which it would be inexcusable to neglect. "*Scitum est periculum ex aliis facere, tibi quid ex usu siet*" is as sound a piece of advice now as it was 2,000 years ago, and to no one does it more forcibly address itself than to the young engineer. The mathematical training every student of engineering now undergoes is somewhat apt to give him an excess of confidence in the exactness of his own deductions, little less objectionable in its practical effect than the timid and slavish adherence to precedent evinced by the proverbial "practical" man. He is, by the same system of training, led to form a ridiculously low estimate of the extent to which the most approved practice of the present day is indebted to inductive processes. By far the larger proportion of the varied problems the civil engineer is called upon to entertain will be most readily and satisfactorily solved by deducing the required result from certain data previously arrived at by the process of induction. In one respect the science of engineering differs from most of the other exact sciences, inasmuch as it is seldom necessary to investigate any problem extensively by induction; the practically correct, and not the theoretically exact, solution is the requirement of the engineer, and it is, therefore, merely necessary for him to trace back sufficiently far to allow of that end being attained. Thus, an analysis of experiments on the transverse strength of beams indicated the existence of an element of strength dependant upon the form of cross section, and varying with the nature of the material; and in the same manner the resistance of long columns has been found in practice to be higher than theory indicated. In each of these instances it is only necessary for the engineer to ascertain enough of the laws governing the increased resistance to enable him to include that element in his calculations, and it is not necessary, although it may be interesting, to ascertain the first cause of the anomalies exhibited in many of the experiments.

The structures falling within the province of the civil engineer are generally so far analogous as to render the ordinary plan of procedure by deduction quite justifiable; but with the mechanical engineer it is otherwise. The conditions under which his works are placed are so involved, and they are so often liable to strains of literally indeterminate amount, that any attempt to generalize would be perfectly futile. Thus, given the resistance of a cylindrical bar of wrought iron to a bending, and also to a twisting stress, who could presume from such data to deduce the proper proportions and sections of the crank shaft of an inside cylinder locomotive? It would be necessary to eliminate the bending stress, and that alone would be made up of the several elements due to the reaction of the driving wheel springs on the roughest portions of the line, of lateral blows on the flanges of the wheels, of the steam pressure on the piston, and of the *vis viva* of the gear and the crank shaft itself. When we consider the *form* of the member which has to sustain these constantly varying stresses, in conjunction with torsional and other strains, it is very apparent that the necessary section and the most economic distribution of the material could only be arrived at by a strictly inductive process. Who, again, could attempt to compute the section of tyre desirable for the driving wheels of the same engine, and yet the practical identity of the proportions adopted by the different makers in this and in other countries, both for the tyre and the crank shaft, clearly prove that these apparently indeterminate problems have been solved by induction with as much exactness as the tensional strength of a two inch square bar may be arrived at by deduction from that of an inch square bar. These considerations should prove reassuring to the civil engineer when confronted with problems of more than average intricacy.

Complex formulæ are rarely resorted to by experienced practical men, the reason for which will probably be found in the fact that too great attention to minutia in the calculations is apt to make a man imagine that the chief portion of his work is accomplished when he has solved the problems relating to strains in the structure, and so induce him to overlook some apparently trifling practical detail, the neglect of which might, after all, be of sufficient moment to cause his work to be classified as a warning rather than as an example. No intelligent engineer, when designing a complicated structure, hesitates to throw over entirely his theoretical deductions, should the proportions thus determined appear unsatisfactory to the eye, because experience has taught him that, in nine cases out of ten, the discrepancy between the proportions deduced and those anticipated is due to the falseness of the hypothesis upon which the theoretical conclusions were based, and not to any error of judgment in that very trustworthy guide—the experienced eye.

We doubt whether that historical *faux pas*, the continuous fish-bellied rail, is justly credited to a member of our profession. We think the idea must have originated with some worthy mathematician, who fondly imagined that perfection was approached in exact proportion to the number of decimal places in his calculated ordinates. A purely practical man would, we feel sure, have instinctively rejected the pseudo-scientific form, although he may not have been able to point out the error in the hypothesis to which the vicious result was due.

Many other instances might be cited where purely theoretical deductions are equally at fault; as a case in point we may refer briefly to the bracing of a bow-string bridge. Numerous and elaborate formulæ are to be found in French and German text books, professing to define the exact value of the maximum strain occurring upon each tie and strut under the passage of a moving load, but unfortunately in nearly every instance these formulæ are based upon the hypothesis that the system is perfectly rigid, or, in other words, that the length of each member of the bridge will remain constant under every degree of strain. Now we know that some deflection must necessarily follow the application of each successive increment of load, however small, and we know also that such deflection could not take place unless the length of every member in the bridge differed, plus or minus, from its original amount. This of course is due to the elasticity of the material, and the complicating conditions thus introduced are so embarrassing, varying as they do with the relative sectional areas of arched rib, tie, and bracing at each portion of the length, that it would be an almost endless task to deduce the exact mathematical value of the maximum strain occurring upon each member of a bowstring bridge under a rolling load of known intensity. No intelligent engineer wastes his time in the investigation of such problems, because he knows that after all the result of his labor would be of no practical value.

It would have been assumed that the whole of the metal in the bridge was in a state of molecular equilibrium in the absence of any external stress, or else that certain members were subjected to initial strains of known intensity. To enable the first hypothesis to obtain, the bars and plates would all have to be of precisely the required length, and accurately fitting, whereas in practice we know that in the process of riveting one bar would be drawn up tight, whilst probably the adjacent one would be quite slack, or even present a permanent lateral curvature. Or, again, in putting the girder together it may have been necessary to "draw out" one of the ties to make it fit into its place, and, probably enough, it would have been riveted up when quite hot; but this apparently trifling, and certainly unavoidable, practical contingency would be sufficient in many instances to augment the laboriously deduced theoretical strain as much as 50 per cent. If cotters were introduced, either for the purpose of securing uniform or initial strain, the value of the result would be entirely dependent upon the intelligence of the men entrusted with the cottering up; and with the best arrangements the degree of uncertainty would be little less than the previous instance. It is quite possible to obtain, by mere inspection, the strains on the several members of a bowstring bridge within 25 per cent. of the amount which would be given by the most elaborate mathematical analysis; consequently, remembering that it is impossible to make sure in practice of approximating even within 50 per cent. to the exactly deduced result, we think the adoption of an elaborate method of calculation for the minor members of a bowstring bridge, and for similar reasons for the strains upon an almost infinite variety of other structures also, only serves to prove that the conditions of the problems are imperfectly appreciated by those attempting to solve them.

HORSE POWER.

From a paper read by J. S. Holland, C. E., R. N., Assoc. I. N. A., before the Institution of Naval Architects.

The principal use of the steam engine at its first introduction was to pump water out of mines; it easily followed that the new engine should be compared with horses then in use for pumping, hence the term horse power of an engine. Watt would undertake to make an engine do the work of so many horses. Being generous he considered that a horse could raise 33,000 lb. one foot high in a minute; he fixed upon that for his horse power. And although he knew that the mean pressure per square inch of his piston would be more than 7 lb., he, to avoid all cavil with his customers, generously fixed upon 7 lb. as one of his factors in calculating horse power.

Knowing that a long stroke engine could work easier at a high velocity than a short stroke, he formed for himself a table of velocities of pistons for various strokes, and, at the time, it was formed on sound principles. So far as marine engines are concerned that table has long been obsolete. The 7 lb. are still retained, but the engineer is allowed to fix his own velocity of piston in his tender on negotiation with the shipowner. This brings me to the subject of this paper. It is the false statement in the tender that I object to. Let us see what takes place at the beginning of a pair of marine engines. Assume that after every consideration has been given to the subject, a power of 6,000 horses will have to be developed. He calculates what he can do in the way of pressure on the piston, he then fixes his velocity, which being determined, the diameter of cylinder follows as a matter of course; he then determines the firegrate and heating surface of his boiler, and the work is done. All this time he has never thought of such a thing as nominal horse power. Yet there is something else to be done. If the shipowner likes to have his engines working up to six times their nominal horse power, clearly there is nothing left for the engineer but to christen his engines 1,000 nominal horse power, and if the shipowner likes to be cheated a little more you have only to christen the engines 600 nominal horse power, and you have ten times the nominal horse power. You may accommodate the shipowner to any extent, but you must not tamper with the power to be indicated.

A case is now before me. An engineer stated in his tender that the revolutions would be 44 per minute, in working they went more than 88 per minute, the pressure was about 22 lb. Now, the pressure being over three times the nominal and the velocity twice, he counted over six times the nominal horse power, and was patted on the back accordingly. If we are to have nominal horse power retained, we must stick to the old 7 lb. and reckon fairly and honestly the velocity expected. Then, if the engineer has made no blunder the engines will move very near the expected velocity, and if they do and give out three times the nominal power, we know that there was a pressure of about 21 lb. In the case I have named the engineer knew well that his engines would go 88 revolutions; he made his screw and his boilers to suit the number of revolutions. The question may be asked, why did he give forty-four revolutions? The answer is plain enough: there is a demand in the market for engines that, under one pretence or another, can be said to have contained their nominal horse power so many times in their indicated power, and where there is a demand there will always be a supply. It is against this practice I enter my protest.

If shipowners and shipbuilders knew the

contents of this paper, we would have little more chuckling of six, seven, or ten times the nominal power. If nominal horse power is to be retained let the pressure be still 7 lb.; let the engineer state fairly his expected velocity, and let credit be given to him for getting as much pressure into his cylinder as he can from a given boiler pressure, and for coming near to his predicted velocity.

As for nominal high pressure there is no such thing. As it would be better to keep nominal power and indicated power as wide apart as possible, I would propose that what is very nearly an average, 10 lb., should be taken as the mean pressure. Nominal horse power has been called a commercial measure. If it ever was, it is no such thing now. Engineers know nothing about it; they are required to produce so much effective power, and they set about to do it. It will weigh so much, cost so much, and they make up their accounts.

I propose to abolish the term nominal horse power altogether; it is not only useless, but pernicious. Shipbuilders are not called on to make vessels carry six or ten times their nominal tonnage, and, I ask, why should not engineers be allowed to be put on an equality with them, and have the privilege of calling a spade a spade?

RAILWAY FERRIES.

From a paper read before the Institution of Naval Architects, by J. Scott Russell, Esq., F. R. S.

One of the great unsolved problems of modern engineering is to complete the wanting links of European railway communication by joining Dover to Calais. That is the missing link in the unity of European civilization. It is also the missing link in material commerce. Railway trains laden with the wealth of nations run smoothly down to the banks of the sea on either side, and are there abruptly stopped — rudely broken up—their contents strewed over the quays—craned and laden into ships—uncraned and unladen on the other side—again stowed on wagons before they can continue their second railway journey, and thus, on a short sea gap of some 20 miles, endure more delay, undergo more wear and tear, and cost more money than on a hundred miles of railway.

That which is merely wasteful and costly in the transport of material merchandise, becomes degrading and barbarous when applied to human beings. The transport of civilized human beings between the kingdom of Great Britain and the empire of France is disgraceful to two civilized nations. The traffic of human beings between Calais and Dover frequently exemplifies some of the worst features which have been pictured of the African slave trade. We are told of 150 negroes huddled under the decks of a ship where they have not even room to lie down—where the air is pestiferous—where human beings are willing almost to throw themselves overboard to escape a state of existence that has become intolerable. What we have *seen* between Calais and Dover is, a hundred, or a couple of hundred, civilized human beings, citizens of refined communities, systematically huddled under decks, where there was neither room for comfort, rest, ventilation, cleanliness, nor health. We have seen fifty delicate, refined women crammed into a cell where they had just room to sit jammed together on the floor. Just before starting a benevolent stewardess placed on the knees of each a convenient basin, and, a few minutes later, an anxious husband, descending from the wet deck to inquire after the welfare of his delicate wife, found it hard to endure the close, confined atmosphere to which, nevertheless, he was obliged to abandon her. Which of us has not passed over this purgatory without meeting some intelligent foreigner who swore that never again would he pay such a penalty for visiting England, and never would he counsel man or woman of his acquaintance to undergo the miseries and humiliation of this miserable passage over the sea channel!

In truth, this great international communication between Europe and England is a degradation to all who endure it—a disgrace to three great railway companies—a blot on the administration of a great Emperor; and when we think ourselves the most practical nation in the world, we are really perpetuating a great arterial system of communication which is barbarous and thoroughly unpractical.

It is well, therefore, to consider, in this meeting of naval architects and marine engineers, whether this state of international communication arises from any impossibility or impracticability standing in the way of expeditious, comfortable, and economical means of railway transport over the sea, or whether the causes are moral, financial, or intellectual incapacity in those who have the duty and responsibility of providing this public highway.

First, therefore, I may state that it is not the fault of engineers and naval architects that the public does not now enjoy the advantage of a railway across the sea. More than three years ago an association of Englishmen was formed to carry railway trains across the sea between Calais and Dover. Of this association Mr. Fowler was the civil engineer and I was the naval architect. All the measures which a private association of individuals could take for giving to our nation and other nations a civilized communication were taken. Neither pains nor time were spared, and large sums of money were spent in making every preparation for giving the public this benefit. Unluckily we had to deal with an apathetic public, and with railway companies already in possession of the ground, with rival interests and disordered finances. The same bad political economy which has abandoned the public works of England to private speculation rendered it impossible for this work to be then achieved, except through the co-operation of railways in a state of war and dilapidation. But the technical work had been thoroughly done. The harbors on both sides had been surveyed, and the working plans completed by Mr. Fowler; the designs of the ships to carry the railway trains across the sea had been completed by myself, and there, on the table, is the model on which they were to be built. The Act of Parliament was applied for, the money for all the expenses was found, and it was not the blame of engineer and naval architect that the thing was not then begun, and now done; there were no engineering difficulties not then solved.

I am now to have the pleasure of bringing before you, not the proposed plan for bridging the sea between Calais and Dover, but a similar undertaking which has been executed, and which is now in successful operation across a sea on a smaller scale. The channel between Dover and Calais is 20 miles, and the sea of Bodan is at most 10 miles to 12 miles broad. There is the same difficulty of shallow water and narrow harbor entrance as at Calais, but extreme low water is rather shallower, and the harbor entrance narrower than at Calais. Of course there is no Atlantic wave, and no ocean ground swells, and therefore no low, long swelling *bas vis*, and, consequently, never in the worst storm the great motion of our seas. But there is, to an even greater extent than on the Channel, the sharp, short, breaking wave, which is both more dangerous and inconvenient than the long low swell; there is the terrific hurricane that swells down from the Alps, and which is probably not inferior in strength to a heavy Atlantic gale, and there are quite as many days in the year when no steamer can venture across the sea of Bodan, as when no steamer can cross the Channel. I think, therefore, the sea of Bodan is a fair scale on which to test a plan for conveying trains across the sea. Take it as half the distance with waves half the size, wind half the strength, harbor entrances half the width, and a steamer half the length, and it will probably be considered as fair an experiment as can be tried.

The peculiar circumstances of this case are such as to present many difficulties, which need not be presented either at Dover or Calais. At Dover there is plenty of water; at Calais there is means of getting as much water as can be wanted, and an Emperor who has cut his way through the Isthmus of Suez can easily dredge a little sand out of the entrance to Calais; but on both sides of the sea of Bodan the water is shallow, while in the middle it is deeper than the Channel.

The entrance to the harbors in this lake is less than 100 ft. of clear width, and one of them is so narrow inside as to be only two ships' lengths. The ports, therefore, present greater difficulties than Dover and Calais; but there are no tides; that is to say, no daily rise and fall of the water; nevertheless there are periods of rise and fall of 10 ft., or, again, about half the ordinary ranges between Calais and Dover.

The Sea of Bodan, or Bodan Sea, or Lake of Constance, is an inland fresh water lake, 60 miles long and 10 to 12 miles wide. It separates Switzerland from Austria, Bavaria, Würtemberg, and North Germany, all of which have railway communication with Switzerland, and through Switzerland with central and southern France, which is cut off short and stops abruptly on the shores of this lake, and this natural barrier of the lake is prolonged right down into Italy by the impassable Alps. The railway trains which last year fed France from the cornfields of Hungary, carried a continual stream of grain across Switzerland into France; but on the edge of this lake all this traffic was stopped—all the grain that might have passed right through in a wagon, from Pesth to Lyons, had to be unladen from one set of wagons at Lindau, in Bavaria, or Friedrichshafen, in Würtemberg, shipped into steamers or barges, unshipped on the other side, and reladen into a new set of wagons. The cost and delay of this system, the accumulation of empty or laden wagons on both sides, the army of men for moving the sacks from ship to land, and from land to wagon, the accumulation of sacks on quays and under sheds, caused a hindrance, an inconvenience, and an expense, to avoid which many preferred to send their wares a long way round.

The impediment for passengers across the Bodan Sea was similar to that between Calais and Dover, although the accommodation for passengers on both sides presents those facilities which have only quite recently been introduced in our harbors, for on both sides of the lake the Swiss and German trains convey the passengers alongside the quay at which the steamers lie, and the passengers present to the companies this advantage over goods, that they are able to tranship themselves at their own inconvenience only.

Under these circumstances I was asked by M. Boller, an eminent Swiss engineer, and M. Schweizer, an able Swiss railway director, whether I would undertake to design a communication across the Sea of Bodan by which railway trains and locomotive engines should pass continually over the sea without interruption, and without change of carriage, so that a bale of goods, or a passenger, placed in a carriage in Switzerland, or in Germany, should pass right through from Vienna, Munich, Stuttgardt, Dresden, or Berlin to Zurich, Lucerne, Bale, Geneva, Lyons, Marseilles, or Paris, or contrarywise to it. It was also a condition that I should, if possible, employ no steam engines, machinery, or power of any kind in the transfer, except the ordinary locomotive engines employed in dragging the train; in short, I was asked to make an international communication across this sea as continuous and unbroken as between two stations on land.

This I have now accomplished, and after frequent preliminary trials it is now doing its daily work of railway communication. It takes trains of 14 to 16 laden wagons at one time. The wagons weigh 70 to 80 tons, their contents 150 tons; they make the passage from harbor to harbor in from forty to fifty-five minutes, the difference being the index of the severity of the weather. The cost of the goods per ton per mile, varying with the quantity on board, is from three farthings to five farthings, including interest on capital, depreciations, and repairs. A locomotive engine on one side places the train on board; a locomotive engine on the other side takes it out. No peculiarity is required in the engine nor in the mode of working it. No peculiarity is required in the wagons, carriages, their brakes, or their construction. The embarkation of a complete train occupies five minutes, its debarkation five minutes. All the practical difficulties which were anticipated and feared have disappeared with the actual facts, and that which was pronounced as so many new or impossible enterprises is now acknowledged to be "kinderspile," or child's play. Indeed, now that it is done, the thing seems so obvious and simple that on returning home across the English Channel by the Straits of Dover, I was totally at a loss to conceive the reasons which could induce the intelligent English people and the great French nation to continue to endure the evils of this barbarous passage across the sea, while little Switzerland and little Würtemberg had provided for a less sea a convenient and unbroken highway.

I will now shortly describe the means by which this railway passage over Lake Constance is accomplished. The Swiss railway which passes from Zurich to Romanshorn, on the Bodensee, is called the Nord-oest-bahn. On the opposite side the German railway terminates in Friedrichshafen, and is one of the royal Würtemberg lines, constructed and worked by the State. Both harbors are so shallow that 6 ft. is the maximum draught of water given for the ship. To carry the prescribed load of 14 to 16 carriages, two lines of railway are necessary on the ship throughout the length of 220 ft. For this purpose alone 22 ft. of breadth are necessary, and as engines and boilers have to be placed on both sides of the railway, the ship has a breadth of nearly 40 ft. without the paddle-wheels, which being each some 10 ft. wide, the boat over all has a width of 60 ft.

The vessel itself, standing in its place in the harbor, appears to form a railway station, the land lines of railway being continued straight on throughout the length of the ship. The vessel has two decks, one below the railway train and the other above it. The upper deck forms a great part of the strength of the ship; double sides of iron plate connect the upper with the lower deck, and convert the whole body of the ship into an iron girder 25 ft. deep at the centre, a construction which gives great strength to the body. The upper deck is the working deck of the vessel, from which the captain commands the engines, and where there are also two steering wheels for the pilots. There is a rudder at each end, so as to save the trouble of turning in the narrow harbors. Each paddle-wheel can be worked independently of the other, and each has two steam engines, so as to work readily and quickly, the four steam engines making up 200 horse power to propel a ship of 1,600 tons. The upper deck does not extend quite to the ends of the boat, so that passengers in carriages occupying the ends are left free to enjoy the Alpine scenery without leaving their carriages, and those who prefer a change, find on the elevated deck a fine weather promenade.

The difficulty of uniting this ship to the railways on either side, so that the trains can run on and run off without the aid of any steam engines or machinery beyond their own locomotives, is overcome by means of a bridge in the air, suspended by heavy weights, capable of adjustment to the rise and fall of the water; and there is in the vessel a further provision to lower or raise her own extremities through a range of five or six feet, so as to diminish the inconveniences of the varying water level. There are, moreover, in the ship self-moving capstans, by which the engines can perform any exceptional manipulation that may be required either for the railway trains or the ship itself.

It is by this combination of all these contrivances that a navigation, which would otherwise have been impossible, has been rendered easy and certain. These rudders and the two independent pairs of engines are an invaluable security against accidents, for one rudder being damaged, or its steering gear broken, an independent steering apparatus is ready for immediate use. In case of accident to either engine, or either paddle-wheel, the other wheel with its pair of engines is ready without a moment's delay to continue the voyage, and this experience has already been obtained, and the ship has performed a trip in less than an hour with one wheel and its engines; 15 deg. of the rudder were found sufficient to steer a straight course, leaving an available steerage of 30 deg. each way to direct the ship, and her captain found no difficulty in entering the harbor and placing the ship.

There is another result of the arrangement of engines adopted in this case, which has proved of the highest practical value. Each wheel has a pair of oscillating engines similar to those of the Great Eastern. I designed the paddle-wheel engines of the Great Eastern so as to be able, like these, to work each paddle-wheel independently of the other, and the result has proved, in this instance, to be of great importance. When large vessels come into shallow water they are well known to steer wild, and their rudders cease to control their movements; by the prompt action of the independent paddle-wheels, which can be made to revolve either in opposite directions, or in the same direction, one fast or one slow, or one altogether stopped, there is no evolution performable by a rudder which cannot be quicker and more handily done by the wheels alone, and this paddle-wheel steerage in shallow water, and in the entrances of harbors, has this great advantage, that it can be performed without way on the ship, or with as little speed as you choose.

For this particular case steerage by wheels has been found of greater value, and I dwell on it because there are some difficulties in the way of its successful execution. The engines must be contrived, as those of the Great Eastern were, for prompt reversal; a code of signals must be contrived so that at the same moment the captain can give different or contrary orders to the engineers of opposite engines; not only so, but the code of orders, to be successful, must give more precise instructions to the engineer than are commonly given. The contrivance of this code and its use require superior intelligence in the captain and in the engineers; but the result has been found to be well worth the pains. The captain has a conning platform in the centre of the upper deck, and thence a speaking tube to each engine-room; each engine-room has also an index which shows the engineer of one what the other is doing. The captain has also two indices on deck which show him what each engine is doing, and so the captain and his two engineers are always at one, and thus a mistake is no sooner made than seen and remedied.

With a proper code of signals and the arrangement I have described, an intelligent sailor will readily see that he can do everything he wants; he can reverse the course of his ship in four, three, or two minutes, according as he uses both engines—one standing, or one reversed. When at rest, he can revolve on a pivot without moving; and when he wishes to run on a circular arc, he has only to order the right number of revolutions to be made with the outer wheel, and a smaller number to be made with the inner wheel, and the curve is described as accurately on the water as with a pair of compasses on a sheet of paper. To steer straight without a rudder is performed by each engineer watching the index of revolutions of the other engine, which is close to the handle governing his own, and with an occasional hint from the captain. After a a little experience this becomes quite easy.

As to the manœuvering of the trains and placing them on the ship, the arrangements are so simple that all difficulty has disappeared; and whereas it was supposed that sufficient experience might only be gained after serious accidents, the experience has been gained and the daily work proceeds without accident. No locomotive engine—not even an empty wagon—has been sent into the sea—events confidently expected. Carriages intended to cross the sea are left at the siding which leads to the ship. The locomotive engine which does the work of the station goes behind this train and pushes it on to the ship, one half on one side, and the other half by a second line on to the other side. The common brakes of the train and of the engine suffice for all the manipulation of the train, and there are special means in the ship herself to prevent the trains at sea from fetching way. In practice the locomotive engines do not cross with the trains, for the Germans prefer their engines and the Swiss theirs. Only carriages and wagons go right through, and instead of 30 tons of locomotive, 10 tons of carriage, and 20 tons of goods more profitably occupy its place.

I trust this verbal description, together with the official plans from which the ship was built, will give a sufficient idea of the manner in which the crossing the Straits of Dover may be safely undertaken and successfully executed; some of the difficulties are greater, and some are less. There is deep water at Dover, and Calais can be easily deepened. The boats must be twice as long, and can be made twice as fast. Suspended bridges can easily be thrown from the land to the ship, as I have done; but with the changes necessary to the greater and continued variations of the tidal waters. In these larger and faster ships there can be room, comfort and ventilation, and, if built with the proper kind of stability, sea-sickness will nearly disappear. The comfort of taking your bed-carriage in London, and not having to leave it till you awaken in Paris, need not be enforced, and the economy and expedition which must arise from sending goods right through to their destination without change of carriage or wagon is thoroughly appreciated by all merchants and shippers. That the trade of Europe with England would enormously increase who can doubt. and the mails of India would reach Brindisi or Marseilles in the same carriages in which they would be stowed by the post-office officials of St. Martin's-le-Grand. The question as it stands is, therefore, whether patient Englishmen will remain quietly content that the communications of their railway traffic between England and all Europe should continue in their present condition of barbarism.

In conclusion, I must say that it is not me the English people have to thank for having made this experiment for them, to show them the practical way of continuing railway traffic over a wide sea on a large scale. I have already said that the problem was proposed to me by M. Schweizer and M. Koller, and not by me to them. The plan was first practically taken up by the President Escher and the Direction of the Nordostbahn, a railway managed and made by the Swiss, completed and set to work on less than its estimated capital, and in consequence of the wisdom, economy and purity of its management, now paying its shareholders a steady eight per cent. The proposal on their representation was willingly accepted by the Government of the small kingdom of Würtemberg, which has conferred on its people, by economical state management, a complete network of railways, at very small cost. These two bodies undertook to carry through this improved communication for their mutual benefit, and its management and government is now incorporated with that of the railways. Having previously built an iron ship, which has for twenty years done satisfactory duty on the same lake, I was asked to prepare the plans of a ship which should fulfil all the conditions of speed, safety, and manageability, which the circumstances required, and also of the works on land necessary to communicate with the ship. These plans of the ship, when prepared, were sent for public tender to several of the best firms in England, Scotland, France, Germany, and Switzerland, and it was intimated to them that if they chose to send in a design of any ship better, safer, or more economical, on a plan of their own, such a plan should have a preference over my own. The result was the acceptance of a tender by Messrs. Escher, Wyss & Co., of Zurich—a firm which, in the third generation, enjoys a high reputation for having covered the lakes of Switzerland with excellent steamships. They ordered the iron for the ship from the Creusot Ironworks in France, the pumps from Berlin, the capstans, anchors, and cables from England, and their performance of their contract has been accepted as satisfactory. The works on the land at Romanshorn were executed under the direction of M. Seits, the resident engineer of the Nordostbahn, and those at Friedrichshafen under the direction of chief engineers and architects Brockman, Binden and Grund.

THE FISH-JOINT.—It is generally known that the original fish-joint, as shown in figs. 1 and 4, was invented by Mr. W. Bridges Adams, of London, and patented by Adams and Richardson. It is not generally known that this excellent device, as at present used (figs. 2 and 3), was developed by Mr. Peter Ashcroft, engineer of the South-Eastern Railway. Mr. Ashcroft's

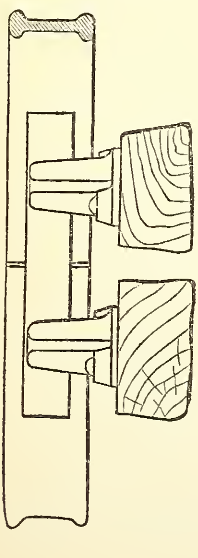


Fig. 1.

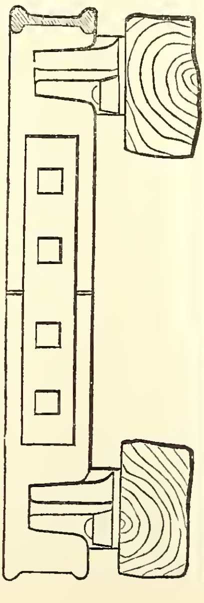


Fig. 2.

Fig. 3.

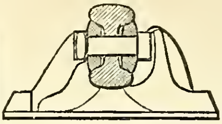
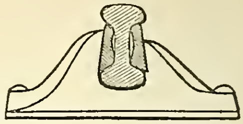


Fig. 4.



claims are thus set forth in a recent letter of his to Mr. R. Rice Williams, and published in "The Engineer":

South-Eastern Railway, Engineer's Office, March 10th, 1869.

My Dear Sir: In reply to your inquiries respecting the origin of the fish-joint used on railways, I beg to say that Mr. W. B. Adams properly describes the title of the patent as about the period referred to, viz., 1849–50. I was then and previously superintendent of the way and works of the then Eastern Counties Railway. When the fish-plate or wedges (see tracing) were first brought to my notice, I practically saw that a better form of suspended joint could be made by substituting bolts for the wedges; and at that time I had a foreman joiner of the name of Franklin (who now resides at Bishop Stortford), to whom I gave instructions to make templates for cast iron fish-plates. These were put down on the line between London and Stratford. They, however, did not answer, inasmuch as, from the unfitness of cast iron, they broke.

They were, however ordered by the Eastern Counties, and paid for by that company. The quantity was very small, that company having, up to the present time, the privilege of using them without any royalty whatever.

Immediately afterwards other patterns were made for joint-plates in wrought iron, and a large quantity were ordered; and, subsequent to my leaving that company's service, the majority of the company's lines were laid with them.

The old rails were punched for bolt-holes by a machine procured from Parr, Curtis & Co., of Manchester, which was driven by a small locomotive engine—the wheels of which were taken off—that had been used for road-inspecting purposes.

About the time first mentioned the firm of Adams & Co., of the Bow Works, got into some little difficulties; and as it appeared to me that the fish-joint patent was likely to become of value, Mr. Jos. Samuel agreed, and did pay, Mr. W. Bridges Adams, or his brother, Mr. Charles Adams, the sum of £2,000 for his entire interest in his patent, which was paid, and the patent became the joint property of Mr. Robert Richardson, Mr. Samuel, and myself, for having had a very considerable share in perfecting the invention. I applied to the two gentlemen before mentioned for my due share in the profits arising, or likely to arise, from the improved suspended joint; and, as a proof of the reasonableness of my claim, I may mention that Messrs. Richardson and Samuel assigned over to me one-sixth share in the patent relating thereto, which I herewith submit to you for inspection.

You have my full permission to make whatever use you please of this communication.

I forward you tracings of Adams' and Richardson's patent wedge-joint, and the after improvement carried out by myself.

I am, dear Sir, truly yours,
(Signed) PETER ASHCROFT.

HISTORY OF DECARBURIZING IRON.

No. IV.

FURNACE FOR REFINING IRON.

JOHN C. McMANAWAY, Scioto, O.—1842. June 22. (U. S.)

NOTE.—*No specification published.*

FURNACE FOR PUDDLING AND REFINING IRON.

PETER COOPER, assignee of JOHN S. GUSTIN, New York.—1842. August 22. (U. S.)

NOTE.—*No specification published.*

PUDDLING FURNACE WITH HEATING CHAMBER.

BODMER, JOHN GEORGE.—1843. Oct. 5. No. 9,899.

This patent is for to nine distinct inventions; that referring to the subject under consideration is as follows:

7th. A double furnace is constructed, having one fire-place in front, while the back part is divided by a horizontal division or shelf into two compartments, an upper and a lower one, each having its own bridge, and each connected with a separate chimney. The lower compartment serves as for the puddling process, and when that is completed its chimney is closed with a dampei, and while the balls are being made and removed, all the blast flames and heat pass into the upper compartment, where the iron undergoes "a kind of refining process," and is afterwards dropped down into the puddling compartment, through a slot in the upper bridge. The improved movable grate (described in the 4th section of the patent), may be applied to puddling furnaces.

[Printed, 1s. 9d. See "Mechanics' Magazine," vol. 40, p. 271; and "Engineers' and Architects' Journal," vol. 7, p 153.]

NOTE.—*The function of the upper chamber can be hardly anything but* HEATING, *or perhaps partially melting, the iron preparatory to puddling. See Gardiner's patent of* 1788. (*Van Nostrand's Magazine, No.* 4, *page* 358.)

FURNACE WITH A LOW GRATE, THE BLAST INSTEAD OF DRAFT, AND HOT AIR FORCED IN ABOVE THE FIRE—ALSO REFINING BY JETS OF HOT AIR.

DETMOLD, JULIUS ADOLPH.—1843. Oct. 18. No. 9,911.

Improvements in "furnaces or fire-places," &c. The invention is intended to obviate the disadvantages arising ' from the formation of combustible gases in the furnace, and the passing of undecomposed air through the grate," and also from cold air being "drawn into the furnace through the door when open, and through every opening or crevice" in the furnace.

These objects are to be effected, 1st, by making the grate much deeper than ordinary, from three to five feet, according as the coal is caking and bituminous, or light in quality.

2d. Instead of relying on the draft of a chimney a blast is forced into the ash-pit below the grate (the ash-pit having an air-tight door), and up through the grate. The body of fuel, except the stratum immediately above the bars, will not be maintained at a high heat, and all that is combustible in the fuel is converted into combustible gases.

3d. The "combustion of these gases" is effected "by forcing amidst them, in their passage over the fire bridge, heated and compressed atmospheric air" supplied from pipes heated in the chimney, and regulated by valves, and introduced through a row of tweers placed in front of the bridge. The pressure of the air within the furnace must always exceed that of the atmosphere. Any kind of coal may be used, and anthracite is particularly beneficial. These closed furnaces are specially adapted for the manufacture of iron; and the specification and drawings describe how they are to be worked. In refining iron, a blast of hot air is directed on the iron through tuyeres converging towards the center of the hearth, and having a pitch of twenty-five or thirty degrees. Iron may be advantageously refined and puddled in the same furnace.

[Printed, 11d. See "London Journal" (Newton's), vol. 25 (conjoined series), p. 73; and "Mechanics' Magazine," vol. 40, p. 379.]

NOTE.—*Mr. C. E. Detmold patented an improved furnace in the United States, April* 16, 1842, *but no specification is accessible.*

The merits of hot-air jets, PROPERLY APPLIED, *above the fire, are hardly appreciated yet. In some of our forges they are used with success for heating, and save much fuel, for instance, at the West Point Foundry. They form a leading feature in the furnace used for the Pomeroy process.*

This is the first mention of the use of BLAST, *instead of the natural* DRAFT, *in the patent records—now a distinguishing feature of the American, as compared with the English practice.*

PURIFYING LIQUID IRON BY SCRAP IRON, BITUMINOUS SUBSTANCES, NITRE AND OTHER FLUXES, AND BY CURRENTS OF ELECTRICITY.

WALL, ARTHUR.—1843. November 18. No. 9,946.

"Improvements in the manufacture of iron." The operations are divided into two classes.

1st. While the iron is in a state of fusion, two compounds (A and B) are added to it. A consists of a mixture of steel or iron filings or cuttings and rosin, two pounds of cuttings to five pounds of rosin. These are made into balls of five pounds weight each, and are thrown on the iron when in a state of fusion in the smelting or other furnace, in the proportion of one ball to five hundredweight of iron. Instead of rosin, analogous substances, pitch, tar, &c., may be used; a few pounds of charcoal may also be added to the ball. B consists of a mixture of salt, rosin and charcoal (of which the proportions are not given), and is to be added after A has been applied, in the proportion of one pound of mixture to one hundredweight of iron. Instead of salt, other fluxes, nitre or fixed alkalies may be used.

2d. When the metal is "congealing" or solidifying, electric currents are to be passed through it in every possible direction.

[Printed, 3d. See "London Journal" (Newton's), vol. 21 (conjoined series). p. 426; and "Engineers' and Architects' Journal," vol. 7, p. 197.]

NOTE.—*This is the first mention of nitre, now used in the Heaton process.*

BLOOMERY.

SIMEON GUILFORD, Lebanon, Pa.—1843. December 27. (U. S.)

Forge, bloomery, for making wrought iron.

NOTE.—*No specification published.*

PURIFICATION IN PUDDLING, BY SULPHUR(!), NITRE, BORAX, ALUM, SODA AND POTASH, IN DEFINITE PROPORTIONS.

SOUTHALL, THOMAS, and CRUDGINGTON, CHARLES.—1844. February 8. No. 10,038.

"Improvements in the manufacture of iron." These consist in treating iron when in a melted state, while being manufactured into malleable iron, with a mixture consisting of equal parts by weight of sulphur, nitre, borax and alum, with half a part by weight of soda or potash, or one and one-half pounds of the mixture must be mixed with about four hundredweight of iron, in the puddling furnace, if the iron be intended to be converted into malleable iron. If the iron be intended to be converted into steel. it is said that four pounds of the mixture will be required for four hundredweight of iron.

[Printed, 3d See "Repertory of Arts," vol. 6 (enlarged series). p. 244; and "Engineers' and Architects' Journal," vol. 7, p. 321.]

PURIFICATION IN PUDDLING, BY DEFINITE PROPORTIONS OF OXIDE OF MANGANESE, PLUMBAGO, CHARCOAL AND SALTPETRE.

LOW, CHARLES.—1844. May 25. No. 10,204.

Improvements in making iron and steel. The patentee makes a mixture consisting of about 42 lb. of black oxide of manganese, of plumbago 8 lb., wood charcoal 14 lb., saltpetre 2 lb. These materials should be ground fine and well mixed. The mixture is introduced into the furnace in proportions of about 66 lb. of mixture to every charge calculated to produce 480 lb. of metal. The mixture is to thrown on the iron in the puddling furnace two or three pounds weight at a time, and stirred up with the metal until 66 lb. are used, or until the iron is brought to nature. The mixture may be advantageously used in the above proportions, or nearly, in any of the processes of making iron.

In manufacturing cast steel from malleable iron, two or three pounds of the mixture are to be put in the melting pot "to every 30 lb. of cast steel;" or the ingredients may be added in the same relative proportions to the malleable iron while it is being made. "Then the application of a moderate heat will fuse the iron in contact with the mixture, and convert it into cast steel."

[Printed, 3d. See "London Journal" (Newton's), vol. 26 (conjoined series), p. 17; "Mechanics' Magazine," vol. 42, p. 109; and "Engineers' and Architects' Journal," vol. 8, p. 90.]

ORE AND SCALE MIXED WITH CARBONACEOUS MATTER AND USED IN THE PUDDLING FURNACE — SUBSTANCES CONTAINING ALUMINA USED TO CURE RED-SHORTNESS.

RUSHTON, THOMAS LEVER.—1844. June 21. No. 10,233.

"Improvements in the manufacture of iron." The "hammer slack, rolled scale, red ore, calcined ore and other oxides" usually mixed with iron in the puddling furnace, are mixed with pulverized carbonaceous matter in the proportion of "17 up to (but not including) 28 per cent of carbonaceous matter." The proportions of 28 per cent and upwards being claimed by William Clay. (See Patent. —1840. March 31. No. 8,459.) "To 480 lb. of No. 4 pig iron" the patentee adds "84 lb. of Lancashire hematite ore pulverized and mixed with 20 lb. of powdered coke." If the proportion of hematite be increased, that of coke must also be increased.

"Clay, argillaceous ironstone, or other substances containing alumina," ground fine, are to be added to those ores likely to produce "red short" iron, to cure that defect. in proportions of from four to ten per cent by weight of the ore employed.

A mixture in proportions of about 150 lb. of tap cinder containing 71 per cent of protoxide of iron to 150 lb. of Lancashire hematite, 50 lb. of ground Wortley fire-clay, 50 lb. of chalk, and 100 lb. of coke dust, may be advantageously combined and manufactured, either with or without pig or refined iron, in reverberatory furnaces, into malleable iron.

[Printed, 4d. See "Mechanics' Magazine," vol. 42, p. 122; "London Journal" (Newton's). vol. 29 (conjoined series), p. 103; and "Engineers' and Architects' Journal," vol. 8, p. 54]

NOTE.—*The patent of Mr. Clay's referred to is for making malleable iron in a reverberatory furnace, from fine ore mixed with 28 per cent and upwards of pulverized carbonaceous matter. The specification, however, says: "Pig or scrap iron, of a weight equal to that of the ore, may be added with advantage in the furnace, at the time when the ore and fuel are well heated."*

This patent is interesting now, in view of the experiments making and claims set up, for mixing the ore with carbonaceous matter in the Ellershausen process. More carbon than the iron can supply, is necessary to reduce the ore, and the refuse of coal oil refineries is said to be the best carbonaceous material.

SPECIFIED PROPORTIONS OF SALT, LIME AND IRON SCALES USED IN THE PUDDLING FURNACE.

OSBORNE, JOHN JAMES.—1845. Jan. 16. No. 10,470.

"Improvements in the manufacture of iron and steel, and in furnaces to be employed in such and similar manufactures."

To improve the quality of the iron, "a mixture composed of 2 lb of common salt, 2 lb. of fresh burnt or quick lime in powder, and 15 lb. of iron scabs" or hammer slag is introduced into the puddling furnace in small quantities at a time, and melted up with the charge of about 3 or 4 hundredweight of pig iron. The iron is then puddled and made into bar iron. "For making shear steel," to a charge of 5 hundredweight of pig iron, 20 lb. of hammer slag are added while the iron is liquid, and, subsequently, a mixture of "2 lb. of common salt, 2 lb. of quick lime in powder, and 2 lb. of pearlash, or 4 lb. of the common carbonate of soda" (the former is preferred) should be added in small quantities. A violent effervescence ensues, and the mass, when worked, is made in the ordinary way into shear steel. When cast steel is required, the mass is similarly treated with the mixture, but not puddled or balled; or a blast furnace may be employed. The charge is run out in a plate of about $1\frac{1}{2}$ in. thickness. It is cooled with water, the slag is removed, and then the mass is broken up and melted in crucibles. "28 lb. of the plate, with $1\frac{1}{2}$ lb. of green bottle glass, 8 oz. of pearlash or 16 of carbonate of soda" and "8 oz. of black oxide of manganese," will produce excellent cast steel.

The improved steel furnace is then described.

[Printed, 6d. See "London Journal" (Newton's), vol. 27 (enlarged series), p. 94; and "Engineers' and Architects' Journal," vol. 8, p. 331.]

DECARBURIZING MELTED PIG IRON BY MEANS OF MALLEABLE IRON SCRAP.

HEATH, JOSIAH MARSHALL.—1845. August 4. No. 10,798.

"Improvements in the manufacture of cast steel." The invention is described as an improvement on that of Mr. Heath, patented April, 1839. (See Van Nostrand's Magazine, No 5, page 459.) The decarburation of pig iron may be better effected in an apparatus distinct from that in which it is melted. The pig iron is melted in a cupola or other furnace, and run from it at the highest possible degree of temperature, into a refinery or other receptacle capable of resisting very great heat. The receptacle is to be maintained at a high temperature by means "of currents of ignited carbonic oxide gas" and of heated atmospheric air, or by oxyhydrogen or oxygen gas, or other suitable means. "In order to decarburate the fluid iron in the receptacle" to the proper degree, the necessary quantity of malleable iron must be mixed with it "more or less," as the steel is to be "softer or harder. If cast steel of medium hardness be required" equal proportions of pig and malleable iron answer best; but these vary according to the quality of the iron; gray iron requires more malleable iron than white.

To form a judgment, small samples should be taken out, and when cold tested by fracture. The malleable iron may be mixed in the form of scraps, or by preference in a granular form, produced by reducing a pure oxide of iron to very small fragments, and submitting them to the process of cementation, mixed with just that proportion of carbonaceous matter which is sufficient to combine with its oxygen at a red heat in a close vessel; the malleable iron at a white heat is then mixed with the fluid pig iron, and the whole is stirred and kept in a state of fusion. A vitreous flux should be used to defend the surface from the atmospheric air. The assays taken from the fluid mass will show when the steel is of the required quality, and it is then run into molds.

[Printed, 7d. See "London Journal" (Newton's) vol. 29 (conjoined series), p. 230; and "Patent Journal," vol. 1, p. 386.]

NOTE.—*Heath mentions introducing currents of heated air into a finery or receptacle in which the use of fuel is not specified. Here are some of the elements of the Bessemer process, but there is no further intimation of blowing the air* THROUGH *or* INTO *the molten iron, than that a finery is employed. Partial decarburization in a finery, by air blasts, was very old in* 1845. *The fact that Heath specifies such extraordinary and costly means of keeping his decarburizing vessel hot, indicates that he did not know that simple streams of air blowing through the iron would accomplish both the heating and the decarburization of the iron.*

Melting down or keeping in a state of fusion, in a highly heated vessel or furnace, cast iron and wrought iron scrap, to produce cast steel, appears to be similar to the Martin process, of which the particulars are given in another column.

The use of malleable scrap in decarburizing crude iron, was first specified by John Wood, in 1761. (*Van Nostrand's Magazine, No.* 3, *p.* 194.)

PUDDLING BY AID OF AIR OVER THE FIRE; ALSO BY THE AID OF ORE, SCALE AND SLACK COAL.

BOVILL, GEORGE HINTON.—1846. Jan. 31. No. 11,065.

Improvements in the manufacture of iron. The invention relates to various matters, among others:

5th. To a method of puddling iron "by the application of the water furnace, commonly known as Kymer and Lighton's furnace, the same being worked by air blown into a closed ash-pit, and the introduction of air over the fire to consume the gases generated."

6th. To a preparation of cinder foom Cumberland ore or hammer scale, and the slack of anthracite coal or other suitable fuel, "to assist the working of iron in the puddling furnace," and also to facilitate the combination of steel with iron.

[Printed, 3d. See "Patent Journal," vol. 1, p. 179.]

FURNACE FOR AND PROCESS IN MAKING MALLEABLE IRON.

WINSLOW, JOHN F., Troy, N. Y.—1846. March 16. (U. S.)

NOTE.—*No specification published.*

THE USE OF ANTHRACITE COAL IN THE REFINERY FURNACE.

CRANE, PATRICK MOIRE.—1847. April 8. No. 11,653.

"Improvements in the manufacture of iron." These relate to the use of anthracite coal in the refinery furnace. The anthracite is to be previously heated in kilns or in any convenient manner, or used in a state of ignition. It may be used alone, or mixed with other fuel, and effects saving, and is said to improve the quality of the refined iron.

[Printed, 3d. See "Repertory of Arts," vol. 10 (enlarged series), p 306; "London Journal" (Newton's), vol. 31 (conjoined series), p. 277; and "Patent Journal," vol. 3, p. 529.]

CHARCOAL MIXED WITH IRON IN PUDDLING, AND CASTING INTO PIGS FROM AN AIR FURNACE, INSTEAD OF USING THE FINERY.

BLEWITT, REGINALD JAMES. — 1847. May 27. No. 11,723.

"Improvements in the manufacture of malleable iron." The iron, instead of being refined in a refinery furnace, is to be produced from the air furnace commonly used for casting or founding purposes. It is to be melted in the air furnace, and then run out into sand or iron molds, and then subjected to the puddling process. The fuel used by the patentee "is a white-ash semi-bituminous coal of excellent quality." He uses one or two hundredweight of charcoal with each charge of iron of about four tons.

[Printed, 3d. See "Repertory of Arts," vol. 10 (enlarged series), p. 354; "Mechanics' Magazine," vol. 47, p. 552; "Patent Journal," vol 4. p. 30; and "Engineers' and Architects' Journal," vol. 11, p. 46.]

PIG IRON MIXED WITH FORTY PER CENT OF WROUGHT IRON IS MELTED, "SHOTTED" IN WATER AND PUDDLED—OXIDE OF MANGANESE INTRODUCED THROUGH THE FINERY TUYERES.

VICKERS, WILLIAM.—1847. June 19. No. 11,759.

"Improvements in the manufacture o firon." Pig iron is melted with small quantities of wrought iron, such as scrap turnings or filings, and the mixture is run in finely divided streams into water. The proportions vary; for making good ordinary wrought iron, 30 parts of wrought iron turnings, with 70 parts by weight of iron, are found beneficial. If the iron be intended for making steel, the proportion of wrought iron may be increased, and 40 per cent of wrought iron employed. The melted iron is run into a cast iron tray, perforated with half-inch holes, and lined with clay about ½ inch thick, punctured "with holes about ¼ of an inch thick at those places where there are holes in the tray." The iron is dropped in a divided state into a cistern of water about 15 feet below it, and is afterwards worked up into wrought iron in the ordinary way. From three to five per cent of black oxide of manganese may be used advantageously with the melted pig and wrought iron, and may be introduced by placing small quantities in the tuyere holes.

[Printed, 3d. See "Repertory of Arts," vol. 13 (enlarged series), p. 243; "London Journal" (Newton's), vol 31 (conjoined series), p 427; "Mechanics' Magazine," vol. 47, p. 631; and "Patent Journal," vol 4, p. 127.]

THE NEW BRIDGE OVER THE SCHUYLKILL.—The first premium for designs for a bridge at the site of the present suspension bridge over the Schuylkill, has been awarded to Mr. J. H. Linville. The clear span is 340 ft., width 50 ft., including two sidewalks of 8 ft. each. There are two roadways, the upper one being reached by approaches on iron columns, to avoid grade crossing, over the Pennsylvania Railway at West Philadelphia.

THE PROGRESS OF LIQUID FUEL.

From a paper read before the Institute of Naval Architects, by Captain Selwyn, R. N.

No one here will probably be prepared to deny that economy is the order of the day, and I am here to-night to continue from last year, before the Naval Architects' Institute, the history of liquid fuel, and to insist again on the important economy to be derived from its employment in steam ships especially. The experiments on which I was last year at this time engaged, and to which I then referred as taking place in a small steam launch, terminated in ample proof being given that they had not been unwisely undertaken by the Admiralty at the request of Mr. Reed. During a trial of 7 hours 40 minutes with coal, a small boiler fitted to the launch in question evaporated 5,418 lb. of water at the rate of 8.5 lb. of water (from 212°) per pound of fuel, while with oil the evaporation in the same boiler was 12.3 lb. of water per pound of fuel, and the quantity 3370 lb. in 3 hours 45 minutes.* It is to be remarked that the coal was the best navigation steam coal, and the fire was forced as much as the stoker could do it, but this was not done with the oil, because, the boiler being short, too much heat was already lost up the funnel, no more coal could have been burnt, nor could the quantity then burnt have been continued without frequent cleaning of the fires. The oil, on the contrary, was burning as well at last as at starting, and there was no deposit in the furnace or boiler flue. The fire was lighted with wood, or wood and coal, and oil was turned on as soon as 10 lb. of steam were obtained. The steam was generally raised to 90 lb. pressure in about one hour from lighting the fire. There was no smoke, and a white handkerchief could scarcely have been dirtied in the furnace after the oil fire was put out.

The results were so far satisfactory that the Admiralty gave a larger boiler, which had formerly belonged to the Oberon, and sanctioned further experiments. These are still proceeding, though intermitted for a time from causes over which I have no control. I trust they will shortly be resumed. The boiler in question is nominally of 130 horse power, and with coal has evaporated on trial in July 206 cubic feet of water per hour, making her equal on the allowance used at

* Mean per hour :
Coal, 100 lb. .... 706 lb. water.
Oil, 100 lb. .... 1032 lb. water.

Woolwich of half a cubic foot per horse-power to a real power of 412. On that trial she burnt in three fires 13¾ cwt. of coal per hour, and evaporated at the rate of 8.2 lb. of water per lb. of fuel burnt. Now, it may here be observed that it is extremely doubtful if this rate of evaporation could be maintained for any very long time in practice with coal in this boiler. There is, on the other hand, no doubt whatever on my mind, or, I think, in that of any one who has seen the liquid fuel in operation, that whatever it does once it will continue to do for any number of hours or days, if the same quality of oil be used, and the furnace be not altered purposely, because there is no stoking needed, and no deposit of any kind to require removal. The boiler was prepared to burn the oil in the following manner: having been already placed on the wharf of the steam basin for a previous experiment not connected with these, it was only necessary to fill the tanks which were on the top of the boiler with oil, to have them correctly gauged, and to fit a pipe to convey the oil from the tank to the fire-doors, where it entered the injector. Steam was taken from a small boiler placed near the large one, and fired with coal, and by another pipe this was brought to the fire-doors, thence through a superheating coil in each furnace, and, lastly, into the injector, where it met the oil. The boiler was a tubular one, with twelve rows of tubes. These were divided by diaphragms in the combustion chamber and smokebox into three runs as follows: a diaphragm of ½ in. iron plate was pierced full of holes, and then lodged in the combustion chamber, over the fourth row of tubes, thus forcing the products of combustion to return through the four lower rows of tubes alone. Arrived in the smokebox, the heated air met another diaphragm exactly similar to the first over the eighth row of tubes, which forced it to return again to the combustion chamber through the tubes left open to it. From thence it again pressed back to the uptake through the upper four rows of tubes. The object of the holes in the iron diaphragms above spoken of was that fireclay might be plastered on the plates above and below, and be jointed through as it was thought the heat would otherwise soon cause the plates to lose their shape and bend down. It is clear that had they been designed for anything more than an experiment, there should have been water spaces. But as far as the oil burning was carried, the heat seemed to be sufficiently kept down in these plates by contact with the water spaces of the boiler. No attempt has yet been made to ascertain what quantity of water can be evaporated by this boiler with oil, since it was soon discovered that the small boiler could not, evaporating from 3 to 4 cubic feet only of water, supply steam enough to burn the full quantity of oil. It was first necessary to find out the best arrangement of furnace, and this could be done while burning only a small quantity of oil per hour. As the size of injector, its best arrangement, and the quantity of steam required per pound of oil to produce the best effect, were also matters for preliminary experiment, these were the first points to which attention was given. It was found that the oil could be perfectly burnt, as you will see by the tabulated result, without removing the firebars, or in any way altering the furnace so as to prevent coal being burnt the next hour if desirable. That the form of injector giving the best effects was that where the oil was in the internal injector with the steam issuing from an annular aperture round it. That the quantity of steam required for jets would be about 1 lb. per pound of oil burnt. That rough broken firebrick, or whole firebricks, loosely built up on the firebars, were perfectly efficient as governors and distributors of the intense heat generated by the combustion of the oil. These speedily got nearly white hot, and remained so. That the superheaters should be placed in the smokebox preferably to the top of the furnace, where they had been fixed, as giving rise to the least alteration of the ordinary state of the boiler for coal. That the firedoors ought to be made in a different form, *i. e.*, box doors opening with a regulator, and hung from above instead of at the side, and that some other slight modifications would be desirable, though not necessary.

The whole arrangement was then altered in order to establish whether by lining the furnaces with firebrick after taking out the firebars, building up bridges, etc., any better result could be obtained without any diaphragms, which were also taken out.

This part of the experiment has not yet been finished, and I am not, therefore, prepared to give any further information about it now; but I hope to try it thoroughly, since it was under a modification of this arrangement that the extraordinary results I narrated last year seem to have been obtained. The oil supplied during these preliminary trials has been analysed by Professor Church, of Cirencester College, with the following results. It is composed of

Carbon...;............	86.48
Hydrogen...............	7.06
Oxygen, or refuse........	6.46
	100.00

Now, referring to Professor Macquorn Rankine's admirable paper, we find that, in order to arrive at the calorific effect in British units of heat to be expected from this oil, we have to make the following simple calculation :

	Per cent.	
Carbon.....	86.48 × 15 =	13.02
Hydrogen...	7.06 × 64 =	4.5
Total...............		17.52

if refuse be not oxygen ; or,

Carbon....	86.48 × 15 =	13.02
Hydrogen..	6.26 × 64 =	4.00
Total...............		17.02

if refuse were oxyen, deducting $\frac{1}{8}$ its weight of the hydrogen. Thus, in either case we may say that the total theoretical evaporative duty or calorific effect in pounds of water evaporated from 212° Fahr, is 17 or 17.55 respectively. Now the next calculation, taking the figures from the tabulated result at Woolwich, is to be performed thus :

Temp. of feed, 50° Fahr. ; temp. of actual boiling point due to 26 lb. pressure, 269° T b ; const., 212° ; boiling point, T^1. Now the formula is thus :

Evaporation reduced or corrected = evaporation observed ×

$$\frac{1 + T^1 - T f + 0.3 \text{ of } T b - T^1}{966^\circ \text{ Fahr.}}.$$

Then

$$\begin{array}{ll} T^1\ 212^\circ & T\,b\ 269^\circ \\ -T\,f\ \ 50 & -T^1\ \ 212 \\ \hline 162 & 57 \div 0.3 = 17.1 \\ +\ \ 17.1\tfrac{3}{10} \text{ of } T\,b - T^1 & \\ \hline 179.1 \div 966^\circ = .18. & \end{array}$$

Then unity + .18 = 1.18 × evaporation observed at feed temperature 14.22 = 16.77 lb. of water evaporation from constant of 212° Fahr. by 1 lb. of oil against 17.52 total duty to be expected from this particular sample of oil. If other oils capable of giving up to 22 lb. or 24 lb. of calorific effect be operated on, we may expect an equally satisfactory approach to their theoretic value.

It is to be observed that the sample taken for analysis was from the last of the oil, and as we may expect that the whole quantity would be arranged according to specific gravity, perhaps this, which was one of the first trials, got a little advantage in that way, but there could not have been more difference than 1 lb. of calorific power either way.

I would draw particular attention to the fact that during this trial the temperature of the bottom of the funnel was so low as 120° Fahr. I must now point out that the rule adopted throughout the Government trials of calculating the evaporative effect from a constant of 100° Fahr,, though fair enough for comparison at ordinary temperatures and pressures, does not take into account the latent heat due to high pressure in the boiler, neither does it give in any way the actual calorific effect of the fuel in British units of heat, which Professor Macquorn Rankine's formula does.

I have also to observe that in buying oil for heating purposes, as much attention ought to be paid to the chemical analysis showing the proportions of carbon, hydrogen, refuse or oxygen (if any,) as would be done with coal to ascertain from which mine or stratum it was obtained, and consequently what effect it might be expected to produce. There will also be a necessity for a specific gravity and fire test, as adverted to in my former paper.

I will now briefly advert to some other independent proofs of the calorific effect of these oils, as compared with coal.

A boiler plate furnace at Woolwich has been fitted to burn oil after the process patented by Messrs. Dorsett and Blyth, which first converts the oil into gas in a species of retort, or still resembling an ordinary vertical boiler of small size, and then burns it as gas issuing from small apertures in a coal of iron pipe. Here no steam is required ; but I have seen reason to think that in a ship the other apparatus will be preferable, as I do not think there is much, if any, difference in the calorific results, and in the plan I now, use only the oil and steam pipes with the injector are necessary.

However this may be, the results obtained in this furnace, which now burns oil instead of coal, are briefly these :

Seventy-five gallons of oil are used per day, instead of 1 ton of coal, or the sp. gr. of the oil being 1,050 about 780 lb. of oil heat the furnace, which had required 2,240 lb. of coal. This gives us a proportion of 1 to 2.7. But this is not all. The ½ in. iron plate which took formerly 15 minutes to heat now takes 6; thus effecting a saving in time, which those who have seen men waiting round a furnace for the heat to be got on, will do well to appreciate; the proportion here is 1 to 2.5. Now, 780 to 2,240 is 2.7 times the duty of coal, or equal, if we take coal at 7 lb. of water evaporative power to 18.9 lb. of water evaporated by 1 lb. of oil. I am informed that a still more remarkable difference was observed in the time taken to heat armor plate when a small piece of it was tried. The heat is remarkably even and free from scale, and no difference has been observed in trials made as to the usual tests for strength after heating. Since last writing on the subject, several other boilers and retorts have been fitted to burn oil, and are giving satisfaction; but where the proper flame has not been obtained, *i. e.*, the blue glow due to burning carbonic oxide, the results always fall short of the true value of the oil, though still showing a considerable superiority to coal. As regards danger, I will repeat the experiment made here last year with a burning fuse.

But the best answer is to be given by those who have had it in practical operation during the past eighteen months without any accident. It is perfectly true that a gas explosion, though not a very dangerous one, resulting in the singeing or burning the faces of those who do it can be produced, if while there is no flame in the furnace, the oil be allowed to drop on the hot bricks till gas is made sufficient to mix explosively in the furnace with air; and I know one gentleman who has recently insisted on trying this for himself, against his engineer's advice, and who got conclusive evidence of the fact in singed whiskers and a slightly scorched face. One such explosion also took place at Woolwich at the close of a successful day's work in my absence; but there, also, those who did it confessed that it was entirely their own fault, and were not at all afraid of going on afterwards.

If I were to use any process for making the oil into gas before using it, I should prefer, on many accounts, to do this by means of Perkins's coil of hot-water pipe (used some years ago in this city for baking bread), instead of putting a fire under the still.

IMPURITIES IN IRON.

From a paper "on the Molecular Action of Impurities in Iron," read before the Philosophical Society of Glasgow by Thomas Rowan, F. C. S., F. R. S. S. A., Atlas Works, Glasgow.

The impurities contained in iron and steel, such as phosphorus, sulphur, &c., which injuriously affect the good qualities of these metals, have of late been the subjects of much discussion and elaborate investigation. Without wishing to enter into the discussion as to the effects produced by certain quantities of these impurities, I would suggest that these effects may not be entirely dependent on the presence of any one element known to produce them in greater or less degree, but may be intensified or modified by *combinations* of impurities in the same metal. Thus the alleged absence from the Heaton steel analysed by Dr. Miller of the cold shortness which under ordinary circumstances would be due to the amount of phosphorus which it contains, may be occasioned by the presence of the calcium, etc., shown in the analysis. I conceive these results to be due to molecular change, which is variously produced in the iron or steel by these various elements, each element acting in a definite manner on the molecules of the metal, while in some instances the action bears a relation to that produced by some other meterial.

It seems clear that iron and steel are capable of numerous modifications or changes of their molecules or particles, by which different physical properties may be imparted to the same bar or piece. Some of these which are produced by mechanical means, are well known in their general effects. For instance, if Bessemer steel in its cast state be struck violent blows with a hammer it undergoes a disintegration similar to that which is produced in metal possessing the quality of "red shortness," while if the same metal be first hammered gently it will afterwards withstand successfully more violent treatment than that sufficient to disintegrate it in its former state. Again, it is well known that a considerable degree of *hardness* is imparted to blister steel by dipping it, when hot, into cold water, the chemical composition of the bar nevertheless remaining entirely unaltered. The converse result, or the impartation of softness to a hardened steel bar, can also be obtained by mechanical means. A somewhat similar instance of the alteration of molecular structure by mechanical means is to be found in the familiar operation of "chilling," by which certain parts of a casting, which are exposed to this action, are materially altered in internal structure, and have in some cases an extraordinary degree of hardness imparted to them, this quality not being possessed by the metal in its original state, nor, of course, by the other parts of the casting not so treated. In the first of these instances the molecules or particles of Bessemer steel seem to have in its cast or crude state such positions relatively to one another as to cause them to *separate* under the influence of heavy hammering, while under the gentler blows they rearrange themselves, and are induced to take up positions conducive to the strength and toughness ultimately possessed by the manufactured bar.

Some interesting experiments on the action of heat in producing a molecular change in iron wire have been made by Mr. G. Gore, F. R. S., and communicated by him to the Royal Society.*

Mr. Tresca, in a paper on the "Flow of Solids," read before the Institution of Mechanical Engineers in Paris in 1867, thus speaks: "The structure of iron, as composed of contiguous filaments appears to afford an explanation of the causes of the transformation of fibrous iron into crystalline iron after long use; filaments of different natures may also differ in hardness, and the facets seen in the fracture of crystalline iron are nothing but surfaces caused by friction between the particles, arising in the molecular vibrations and consequent elastic changes of form to which iron may be subjected, according to the use it is put to. These facets should never be mistaken for the grain in the iron, which is originally nonfibrous; and an examination with a magnifying glass shows that there is in fact no similarity between the two states." This author also states that he has produced numerous facets by twisting and untwisting the same specimens of granular iron a number of times.

It is to similar molecular action, resulting, however, in these instances from *chemical force*, that I would refer the effects produced on iron and steel by the presence of the various elements denominated "impurities." Thus phosphorus would, on this supposition, be found to act on the molecules of pure iron by inducing a permanent formation or relative grouping of them, which in result corresponds to the quality of "cold shortness" in the metal. Sulphur, while similarly acting on the molecules, would induce a different arrangement of them, and consequently different results would accrue to the metal.

We could understand that in these two instances, the results being nearly opposite, the relative formations would be found to have nearly opposite characters also. It might on this theory be possible, were the effects observed which are produced by various elements, to modify or intensify at will any particular class of characteristics in any given substance; although it is very improbable that any one class of effects could be counteracted by the production in the same metal of those of an opposite class. In case of such combinations a new condition would in all probability result from the complex character of the internal action.

Some careful examinations of the structure of different classes of iron, which are very valuable in their results, and calculated to throw some light on this subject, have been made by M. Schott, of Ilsenburg, and are published in a work on "Iron and Steel Manufacture," by F. Kohn.

M. Schott made microscopical examinations of the fractures of various qualities of cast iron, and also minutely examined the appearance afforded by those irons when passing from the liquid to the solid state. He has also made numerous examinations of the structure of steel, and, as the result of all his researches, maintains that "all crystals of iron are of the form of a double pyramid, the axis of which is variable, as compared with the size of the base. The crystals of the coarser kinds, as compared with those of the finest qualities of crystalline iron, are of about twice the height. The more uniform the grain, the smaller the crystals, and the flatter the pyramids, which form each single element, the better is the quality, the greater is the cohesive force, and the finer the surface of the iron. These pyramids become flatter as the proportion of carbon contained in the steel decreases. Consequently, in cast iron and in the crudest kinds of hard steel the crystals approach more the cubical form, from which the octahedron proper is derived, and the opposite extreme or wrought iron has its pyramids flattened down to parallel surfaces or leaves, which in their arrangement produce what is called the fibre of the iron. The highest quality of steel has all its crystals

* (See *Proceedings* of the Royal Society, No. 108, January, 1869.)

in parallel positions, each crystal filling the interstices formed by the angular sides of its neighbours. The crystals stand with their axes in the direction of the pressure or percussive force exerted upon them in working, and consequently the fracture shows the sides or sharp corners of all the parallel crystals. In reality, good steel shows, when examined under the microscope, large groups of fine crystals like the points of needles—all arranged in the same direction and parallel."

It is thus evident that the presence of other elements or impurities affects, in greater or less degree, the regularity of the structure of iron; and I have little doubt that research, by determining the method of their action upon the molecules of the metal will place its qualities more under control.

THE DARIEN CANAL.

The following abstract of the report of Messrs. McDougal and Sweet, the engineers who surveyed the route of the "San Blas Ship Canal" in 1863, is compiled from a resumé of the report, as prepared for the "Syracuse Daily Courier" by Mr. Charles A. Sweet, one of the engineers above mentioned. The complete and accurate statistics here presented will be found especially interesting at the present time:

Public attention has long been directed to projects of a grand inter-oceanic ship canal, to connect the two oceans at or near the Isthmus of Panama or Darien, and to decrease the distance now necessarily traversed and diminish the time now consumed in going from the ports of either ocean to the other. To that end grants have, at different times, been made by Central American States, or treaties negotiated with them. Surveys of different routes have been completed, and yet no progress has yet been made towards actual construction beyond the survey and estimates of cost.

The recent negotiation of a treaty between this government and the United States of Columbia, securing and regulating the right to construct a canal across the Isthmus, has now revived the long dormant interest in this project.

The Shortest Route—This is the "San Blas" route, about thirty miles long, its cost to be about sixty-five millions of dollars. The surveys were made in 1863 in behalf of Mr. Frederick M. Kelly and others of New York city, under the direction of A. McDougall, Esq., of Massachusetts, now deceased, as Chief Engineer, and Charles A. Sweet, now of Syracuse, N. Y., as principal Assistant. The report of the Surveyors was made to Mr. Kelly in 1864.

General Features.—The whole exact length of this canal, according to the survey above referred to, is but 30.03 miles. It extends from Chepillo Island in Pacific Harbor, on the Pacific Coast, to the Gulf of San Blas, on the Atlantic side. The entire work is divided into four sections. The first section extends from Chepillo Island to "Paneas," on the Bayano river. Besides a dam across the river, a tidal lock at the Great Bend of the river, and a short cut across the Bend, the work on this section consists chiefly of the removal of sand bars in the harbor and river. It is 10.101 miles long, and consists chiefly of excavation for the canal and largely of rock excavation. At the southern entrance of the tunnel through the mountains, the greatest elevation attained on the first two sections of the canal is reached, being 150 feet above the level of the water surface of the canal, or 175 feet above that of the Pacific. The entire route, except near the mountains, is nearly level. The summit of the Cordilleras, through which a tunnel is to run, is, however, 1,500 feet above the level of the same ocean. The soil is shallow, being loam or sand, with rock below, and only from two to five feet deep. The elevation of the surface of the land above the proposed surface of the canal is but six feet near its southern terminus, and but one foot near its northern. The entire canal is to be fed from the Pacific ocean, and its water to be maintained at the level of ordinary high tide in the Pacific. The tides in the Pacific rise from 12 65-100, the lowest flood tide, to 22 feet for the highest; and these create the necessity for a tidal lock of $45\frac{1}{2}$ feet elevation of wall. The tides on the Atlantic side are insignificant, rising only from one to one and a half feet from ebb to flow. The third section is rock-cutting through the Cordilleras, seven miles long; and the fourth section consists of excavation for canal, similar to the work on the second section, terminated by a lift lock. The whole route is a wilderness, without even a hamlet or village upon it, although four miles from it there is one native village of 2,000 inhabitants. The following is the official estimate of the cost of the work by sections upon the survey and plan above referred to:

SECTION NO. 1 extends from the island of Chepillo through Bayano river, to divergence of the canal from it at Paneas, $10\frac{101}{1000}$ miles.

The river is three miles wide at mouth with 30 feet depth of water.

The work on this section consists—first, of the removal of sand bars in Pacific Harbor and Bayano river; second, a lighthouse at Chepillo Island; third, a tidal lock at Great Bend with walls $45\frac{1}{2}$ feet high; fourth, a composite dam at Great Bend; fifth, completion of the Great Bend cut.

The cost of these several works, including draining, chopping, earth and river excavation, embankment, masonry, labor, materials, &c., is estimated as follows:

Removal of bars	$136,684
Light House	12,000
Tidal Lock	675,844
Composite Dam	174,631
Great Bend Cut	209,835
Total cost section No. 1	$1,208,994

SECTION NO. 2 is a canal from Bayano river at "Paneas" to the south end of the tunnel, and is $8\frac{996}{1000}$ miles long.

The levels to the south end of the tunnel were taken by the late chief engineer, Mr. McDougall; the other levels on the entire route by Mr. Sweet, his principal assistant.

The work on this section consists, first, of construction of canal from its point of divergence from Bayano river, at Paneas to the south end of the tunnel; second, of a new channel for the Mamoni river, which crosses the route of the proposed canal, $3\frac{600}{1000}$ miles long.

The cost of the first named work of this section, including bailing, draining, chopping, excavation, embankment, puddling, &c., is	$13,033,943
The cost of the second is	115,752
Total cost second section	$13,149,695

SECTION NO. 3 is a tunnel through the Cordilleras seven miles long. This work is exclusively rock excavation. It consists of a canal of 25 feet depth of water, a perpendicular excavation of 29 feet above the water surface on either side, whence springs the arch rising 561 feet above its starting point on a perpendicular, making 105 feet from bottom of canal to top of arch. The total cost of this work, at $2.50 per cubic yard, is estimated to be $29,316,067.

SECTION NO. 4 extends from the north end of the tunnel to 25 ft. depth of water in the Gulf of San Blas, Atlantic side, $3\frac{733}{1000}$.

The work on this short section consists—1st, of construction of canal; 2d, of a lock with 9 feet fall and walls $38\frac{1}{2}$ feet high; 3d, a lighthouse on San Blas Point. The estimated cost

Of canal is	$11,234,318
Of lock No. 2, or lift lock	506,017
Of lighthouse	12,000
Total cost of Section No. 4	$11,752,335

GENERAL SUMMARY.—The capacity of the tunnel portion of the canal has already been stated. These estimates contemplate, on either side of the tunnel, the same depth of water as in the tunnel, but a greater width of canal. Beyond the tunnel the surface width of canal is 143 feet, and width at bottom 100 feet. The summary of the total estimated cost of a canal of the above dimensions on this route is as follows:

Section No. 1	$1,208,994
Section No. 2	13,149,695
Section No. 3	29,316,067
Section No. 4	11,759,335
Add ten per cent for contingencies and engineering expenses	5,602,809
Add for medical and military departments, interest upon capital during construction and transportation, etc.,	32,500,000
Total	$93,469.800

A second was made and submitted for a canal of less width and depth of water. For this canal, with a width at water surface of 100 feet, and at bottom of 80 feet, and 20 feet depth of water, the estimate cost is summed up as follows:

Section No. 1	$1,005,565
Section No. 2	10,506,669
Section No. 3	29,147,067
Section No. 4	8,862,008
Ten per cent for contingencies and engineering expenses	4,952,131
Add for medical and military departments, interest upon capital during construction and transportation	25,000,000
Total	$79,473,440

We may add that in the judgment of the surviving engineer, Mr. Sweet, 15 per cent instead of 10 per cent ought in this case to be added to the estimated cost to cover contingencies and engineering expenses.

COMMERCIAL ADVANTAGES AND VALUE OF CANAL.—With the estimates of cost there were submitted also certain statistics to show the great value of this projected canal to shippers and to the public. According to one of these statements, the freight paid at San Francisco, on goods from the Atlantic in 1853 alone, being only a part of the trade, as some freights were paid before shipping, was $9,911,432.

At least three-quarters of this charge would be saved, or $7,433,574, or the interest at 6 per cent on a capital of	$123,892,900
The foreign trade of San Francisco would be benefited by one-half the freight, the amount of which paid at port in 1853 was $1,840,650. One-half is equal to the interest at 6 per cent on........................	15,338,750
The foreign Pacific trade to the United States was carried out in 1854 in 961 vessels outward bound and 895 entered home, showing that the trade is equivalent to more than two-thirds of that of California. It would, therefore, in passing through the canal, make a corresponding saving for a sum equal to..................	99,450,570
Thus showing that the canal would save to the United States alone an annual interest on the sum of	$238,682,220

There is also a table showing the number of vessels visiting the ports of the different countries of the Pacific beyond Cape Horn, the tonnage entering those ports, the tonnage and value of their exports and imports. Without embodying details as to the several countries, we give only totals. The number of vessels was 3,693.

The tonnage of imports was..........	1,682,349
That of exports	1,586,349
Total tonnage..................	3,268,698
The valuation of exports was.........	$49,815,000
That of exports	100,188,000
Total val. of exports and imports,	$150,003,000

There was also attached to the report an interesting table, showing the savings in distance from New York to ten of the principal ports of the Pacific by the route of the contemplated canal over the two Cape routes, which we give in full, as follows:

From New York to Ports.	Distance via Cape of Good Hope.	Distance via Cape Horn.	Distance via Isthmus canal.	Saving in miles over Cape of Good Hope route.	Saving in miles over Cape Horn route.
Calcutta........	17,500	23,000	13,400	4,100	9,600
Canton.........	19,500	21,500	10,600	8,900	10,900
Shanghai.......	20,000	22,000	10,400	9,600	11,600
Valparaiso......	....	12,900	4,800	....	8,100
Callao..........	....	13,500	3,500	....	10,000
Guyaquil	....	13,300	2,800	....	11,500
Panama	....	16,000	2,020	....	14,000
Mazatlan.......	....	18,000	4,000	....	14,000
San Diego......	....	18,500	4,500	....	14,000
San Francisco..	....	19,500	5,000	....	117,700
				22,600	117,700

This shows a saving in the several voyages, one to each of the three ports first named, of 22,600 miles over the Good Hope route, and a saving in a single voyage to each of the ports, by way of Cape Horn, of 117,700 miles.

Colonel Totten, in his report of 1866, on the progress of the Panama railroad, has a condensed table, in which he states that after deducting the British trade with Australia, the aggregate tonnage which doubled Cape Horn to and from the Pacific ports was

In tons............................	2,679,600
There had been an actual increase for the ten previous years of 115 per cent. Estimating a like increase since 1855, we have an increase in addition to the above for the eight years from 1855 to 1862 inclusive of..................	2,465,155
Or a total tonnage of...........	5,144,752

The voyage of a ship of 1,200 tons, off Sandy Hook, with a complete outfit, via San Francisco, via Cape Horn, costs $12,000, including running expenses for 145 days, or

Per day..............................	$82 75
In this amount is included the insurance of 13 per cent on value of ship, averaged at $100,000. In consequence of cheapened insurance because of an avoidance of the Cape voyage, the expense per day by the Isthmus route will be reduced to......	64 70
Or a saving per day of..............	$18 05
The total cost of a voyage of 145 days is..	$12,000
Of that of 60 days by canal.............	3,882
Total saving	$8,118
The cost per ton on a vessel of the above burthen, via Cape Horn, will be.......	$10 00
Cost via Ship Canal....................	3 23
Saving of cost per ton..............	$6 77

Taking the statistics based on the report of our foreign commerce of 1853, we had a total tonnage estimated for 1864 of 5,000,000 tons. The total saving on this amount at $6.77 per ton is $33,850,000. If the saving on insurance on cargo as well as vessel be estimated, the saving to commerce would be about the same as that shown by Mr. Kelly.

Conclusion.—It is evident, therefore, from statistics, that with the rapid development of the trade to and from our Western coast, as well as to other ports on the Chinese and Japan seas and the Pacific ocean, the time has fully arrived for the construction of this long-mooted Ship Canal through the Isthmus of Panama; that its construction cannot fail to be profitable to them who construct it, and still more profitable and beneficent, directly to the commercial world, and indirectly to the whole people who produce the articles of that commerce and to those who consume them. And, further, unless this canal be now speedily opened, the rich trade of the Asiatic coast will soon be largely concentrated, either by the Suez canal in European hands, or diverted to the cities of the Pacific slope, to the great loss of our Atlantic coast.

Mr. Sweet, the principal assistant in the survey, the results of which are here given, has been long connected with the public works of New York. He is a man of great practical experience, skill, and unquestioned integrity, well and favorably known to the profession in this State. These pioneer surveys were partly, and the estimates of work and cost were wholly made by him; and since the death of McDougall, the chief engineer, no man could be found better adapted to conduct and superintend this great work to an economical and successful termination than this pioneer in the original survey.

SCREW VS. PADDLE SHIPS.

Extract from a paper discussing the types of steamships, by Norman W. Wheeler.

The extreme depression of late years endured by the European steam navigation interest has produced the natural results of rendering prominent, and of bringing into somewhat extended use, better and more economical types of ships and marine steam machinery. The practical success attending the efforts of Messrs. Randolph, Elder & Co., and others, in introducing economical principles into steamship practice, may properly be taken as good warrant for the adoption here of the same principles. It affords the writer much pleasure to know that able European engineers have independently worked out and made successful general plans which he has persistently advocated for more than twelve years, and in one instance reduced to successful practice.

Many European steamship companies have altered, or are now altering, such of their old paddle-ships as are deemed worth the conversion, to accord with modern economical systems, and the more prominent and enterprising companies have utterly discarded the old and expensive practice comprising non-expansion, salt feed water, slow piston speed, and very narrow, deep ships. A few instances are noted below contrasting the performance of steamers under the old system with that of the same or like ships under the new, the authority being that of the French Society of Engineers.

The French steamer Europe, 2,200 tons, and 900 nominal horse power, consumed an average of 1,158 tons of coal per trans-Atlantic voyage, the mean speed being 10.75 miles per hour. The St. Laurient, with hull and boilers identical with those of the Europe, consumed 1045 tons of coal per trans-Atlantic voyage, the average speed being 11.9 miles per hour. The engines of the two ships, considered by themselves, are practically equal to each other in economy, and the difference in performance is solely due to the substitution of the screw for the paddle-wheel as an instrument of propulsion. The chief gain in this case is in freight capacity; but the passages are reduced by about seven hours, and 113 tons of coal are saved.

These results decided the proprietors of the line to convert the paddle steamer Washington into a twin screw steamer, with improved engines, but without change of hull or boilers. With the former engines and paddle-wheels, the consumption averaged 96 tons per day, and the speed 10 miles per hour. She now consumes 83 tons per day and averages 11.8 miles per hour.

The commercial gain by the conversion is two days time in a trans-Atlantic voyage, 335 tons of coal per passage, and an increase of freight capacity equal to the coal saved. If she were driven at her present speed by the old engines and wheels, the consumption would be 157 tons per day. If she were driven at her old speed by the new machinery the consumption would be 50 tons per day, making a difference of 46 tons per day in one case, and 61 tons in the other.

The Napoleon III averages 10.58 miles per hour, and consumes 115 tons per day. Messrs. Randolph, Elder & Co., have contracted to convert the ships into a twin screw steamer, with their system of steam machinery, guaranteeing a speed of 12 miles per hour with a daily consumption of 70 tons. To drive this ship at the promised speed with the old machinery would require 167 tons of coal per day, and to drive her at the old speed by the new machinery will require but 48 tons; a difference of 97 tons in one case and 67 tons in the other. * * *

The steam yacht Octavia, the property of Mr. T. W. Kennard, is believed to be the most economical ship extant, and the earliest example of compound engines connected directly to the screw shaft. The hull and engines were designed by the writer, some of the leading features having been dictated by Mr. Kennard. The Octavia is a wooden, single screw steamer of 425 tons displacement at mean draft, fitted with one pair of Wolff cricket engines, with steam jackets, four to eight fold expansion, surface condenser, and flue and return tubular boilers. The engines develop 250 indicated horse-power, with the consumption of 300 lb. of anthracite coal per hour; the efficiency being one horse-power per hour per 1.2 lb. coal. With the above indicated development of power and consumption of coal, she runs full 11 miles per hour in calm weather, as has been proved by repeated trials. In a winter cruise lasting 23 days (steaming time), with the wind varying from a full gale to a strong breeze, always in such directions that no sail could be carried, her average run per day was 200 miles, and the daily consumption four tons of anthracite. She is, however, capable of a much better performance. During the whole of the cruise the steam jackets were not used, but allowed to remain full of water, through a misapprehension of the engineers relating to steam traps.

It will be fair to assume that with the power required for a calm weather speed of 11 miles, her mean sea speed will be 9 miles per hour.

It is well known that for similar ships of different tonnage, the power required to propel them at given speeds, below the wave speed of the shortest ship, varies as the squares of the cube roots of the tonnages, and that for different speeds of the same ship, below the wave speed, the power required varies as the cubes of the speeds. These principles enable us to compare the Octavia's performance with that of large commercial steamships. Let us assume a ship of 5,000 tons displacement, having the characteristics of the Octavia, and compare the probable performance with that of the Pacific Mail S. S. Great Republic.

The last named ship sailed from San Francisco September 3d, 1867, and arrived at Hong Kong October 5th, the distance run being 6,623 miles by observations, the running time 691 hours, and the consumption 1,373 tons of coal, making the mean speed 9.586 miles per hour, and the consumption 4,451 lb. in the same time. For a similar speed of 9.586 miles per hour, the 5,000 ton ship will require only 1,848 lb. of coal per hour, which is a trifle more than 0.4 the consumption of the Great Republic for an equal speed.

Were the Great Republic as economical a ship as the Octavia, she would make the trans-Pacific voyage in the same time as now, and consume but 824 tons of coal, saving 549 tons, and adding so much to freight capacity. If the engine power of the 5,000 ton ship were so much increased as to make the consumption per hour equal to that of the Great Republic, the speed would be 12.9 miles per hour, the voyage be performed in $531\frac{1}{2}$ hours, saving $177\frac{1}{2}$ hours time and 352 tons of coal, adding so much to freight capacity. If the engine power were further increased so that the consumption per mile would equal that of the Great Republic, the speed would be 15.38 miles per hour, the consumption for the same time 7,143 lb., and the voyage made in 431 hours, saving 260 hours time.

LOCOMOTIVES FOR LONG RUNS.

Compiled from "The Engineer."

Express trains between important centers must be "through" trains in order that they may be worked with the greatest economy at the highest speed. This condition is not invariably easy of fulfilment; and until the invention of the water trough and scoop, by Mr. Ramsbottom, they probably could not have been fulfilled at all. At this time it is certain that the advantages to be derived from long, continuous runs are not fully realized; and it is more than probable that important changes in the method of working express traffic will be introduced before many years have elapsed. The London and North-Western Railway Company were among the first to perceive the advantages to be gained by traversing distances of seventy or eighty miles without a stop, and Mr. Ramsbottom placed at the disposal of his directors the means of traversing even greater distances without interruption.

The full advantage of the water trough system was not taken, however, until the completion of the great Runcorn bridge; and the novel announcement that Liverpool is to be placed within four hours of London by express train was reserved for 1869. Liverpool is in round numbers 200 miles from London, *viâ* Runcorn, and in order that it may be reached at 4 P.M. by a train leaving London at 12 noon, it is necessary that an average speed of fifty miles per hour should be maintained the whole way. To accomplish such a feat will be no mean achievement; its regular daily performance will be a novelty in railway engineering, and it is worth while to consider what has to be done, and by what manner of engines the work can be best performed. It is obvious that the run from London to Liverpool must be continuous. Each stoppage would consume at least three minutes during which the train would be standing; while an equal time would be expended in the retardation and acceleration of the train.

Whether an engine shall stop or not obviously depends on two things; first, its powers of carrying or taking in water and coal; and, secondly, its capacity for continuous exertion without examination or adjustment of parts. The largest tenders yet made hold little more than 2,000 gallons of water, while, with their frames and wheels, they represent each a load of over twenty-two tons. But the supply of water which these tenders carry would not last for more than a third of the distance to be traversed. Therefore their tanks will be replenished *en route* by the aid of scoops. It is not probable that these express trains will ever be of great length; exclusive of engine and tender they are not likely to weigh much more than seventy tons. The engine we may set down at twenty-eight tons, making a gross load of, say, 100 tons. The addition of a tender increases the whole load moved by say one-fifth, or the load to be drawn by the engine by two-sevenths. At 50 miles per hour the resistance of the tender will average about 25 lb. per ton, or 500 lb. for twenty tons; and, in overcoming this resistance, the engine must do work each hour equivalent to 132,000,000 foot-pounds. And in four hours, that is to say, on the entire run, the duty will amount to 528,000,000 of foot-pounds. Stated differently, more than 66 horse power indicated, will be expended by the engine in hauling the tender alone. As the water is consumed the resistance will be reduced a little; but, all things considered, we are disposed to think that we have under, rather than over, rated the amount of power which will be required to propel a 2,000-gallon tender at 50 miles per hour. Arrived at this point, the first question which suggests itself is, naturally: Is it possible to dispense with the tender? To this our answer must be in the affirmative. Seeing that we cannot do without water troughs, why not have more of them, and replace the 2,000 gallon tender by a 400 gallon tank. It is absurd, practically, to abolish water cranes, and yet to retain an evil which was necessary only because nothing better than the water crane was known. By getting rid of the tender, more weight would be rendered available for adhesion, and all the working expenses would be materially reduced. We are not in a position to state accurately what the expense of additional water troughs would be; but the value of the suppressed tenders, and the economy effected by the suppression would go far to compensate for the extra expenditure.

Reasoning on the foregoing basis, we assume that the best engines for working the Liverpool express would be tank engines, carrying enough water to last them about fifteen miles. As the quantity of water taken in would be comparatively moderate, the troughs might be made much shorter than those now used to fill a large tender; and the scoop arrangements are susceptible of modifications and improvements which would render the work of filling a certainty, instead of depending on the attention of the driver or stoker.

As regards the other characteristics of the engines, it may be taken as proved that they must be large, powerful, and heavy machines. However well light locomotives may answer for moderate speeds and short runs, on the Liverpool trip they would be out of place. The work to be done is heavy, and the engines doing it must be not only well up to their work, but a good deal above it. Outside cylinder engines, on eight wheels, four being coupled as drivers, and four placed in an Adams' bogie in front, would probably answer very well.* The tank would be placed beneath the barrel of the boiler, and a coal-box might run at each side. The cylinders would be 18 in. by 24 in. stroke, and the wheels should not be less than 7 ft. in diameter. Boiler pressure 120 lb. at most, and we should prefer to give the cylinder another inch of diameter, and to reduce the pressure to 100 lb. It will be said that this is retrograde practice, but we know that steam of great pressure and high temperature is very injurious to packing, and even to the iron of the cylinder and valve faces, which it is not easy to lubricate prop-

* This looks very like an American locomotive.—Ed. *V. E. M.*

erly under the conditions, and it is by no means improbable that on long runs, during which no water can find its way to the cylinder, more trouble may be caused by high steam than it is worth—trouble which would not be encountered at all if the runs were short. All the working parts should be stronger than usual, and rubbing surfaces should have much larger dimensions than are commonly given to them.

While considering this portion of the subject it may be worth while to illustrate in a compact form the work which the Liverpool express engines must execute. The driving wheels being 7 ft. in diameter will make 240 revolutions per mile, or 48,000 revolutions in running from London to Liverpool. When traveling at fifty miles an hour, 7 ft. wheels will make 200 revolutions per minute. It will require good fitting and lubrication to enable a couple of shafts running in four bearings, each sustaining four tons, to make 48,000 revolutions without ceasing for a moment, at the rate of 200 per minute, without heating or cutting during the four hours which must elapse before they can receive any proper inspection or attention; and the same holds good of the big ends of the connecting rods, the eccentrics and straps, etc. Each piston will pass through a distance of 192,000 feet, or nearly 36½ miles, in the course of the trip, and the contents of each stuffing box will be at the end of the journey as though a rod of iron 36½ miles long had been drawn through at the rate of 800 feet per minute. We say nothing of the concussive strains due to the speed. It will be seen that the conditions are severer, however, than those under which locomotives constantly work with great success, save in one important respect. When engines stop to take in water, an opportunity is afforded for at least a cursory examination, which an experienced driver is prompt to avail himself of; and it is possible to attend to a hot bearing or to fill up an exhausted lubricator. But the continuous exertion of nearly the maximum power of a large locomotive for a period of four hours is a condition which has never yet obtained in regular railway practice. We have no doubt whatever that the difficulties which may arise will be easily overcome; but we think it highly probable that it will be found expedient to design locomotives for this kind of service which will differ in not a few respects from those types of express engines now regarded as the best possible.

EXPERIMENTS WITH THE RODMAN GUN IN ENGLAND.

The 15-inch Rodman Gun, which some time since gave the British authorities a new idea of American ordnance, has again been fired—at a 20-in. target—with rather destructive effects upon the armor. The result is considered highly satisfactory as establishing the superiority of *English shot!* The "Mechanic's Magazine" gives the following account of the trial:

The gun was laid against the Plymouth casemate at 200 yards range. The powder charge was 83¼ lb. of large grain powder, and the three shots fired weighed 457 lb., 451 lb., and 450 lb. respectively. The new shot are spherical, and are made from a mixture of cast and refined iron at the Woolwich Laboratory, upon the method patented by Dr. D. S. Price, the original material having been first proposed by him to the Iron Plate Committee of 1862, both for projectiles and guns. The three rounds fired were highly interesting, as proving that round shot for large smooth-bore guns can be made in England of superior quality to the American shot. They, moreover, possess this advantage, that whilst the American shot are all turned true by machinery, these shots are cast in moulds with such exactitude as to be ready for use without any such subsequent mechanical operation. The three Price's shots fired on the present occasion were true to the 1-300th of an inch, and passed through the gauging rings both ways with exactitude.

The first round with the 457 lb. shot struck the 20-inch thick portion of the Plymouth casemate, making an indent 15½ in. across, and 5 in. deep, the indent, being saucer-shaped, with very steep rounded sides 9 in. below the indent was a curved crack, 2 ft. 4 in. in length; and, above it, a crack extended diagonally 9 in. to an empty bolt-hole, and thence beyond to the upper proper left corner of the lower portion of the plate. From the above bolt-hole, another crack ran off at right angles to the first. A large triangular piece of the covering plate, measuring 3 ft. 8 in. by 11 in. by 16 in., was carried away. The head of a 3-in. through bolt was also broken off, whilst behind the plate the 5-in. face plate of the proper 15-in. thick structure of the casemate was indented and buckled. At the rear of the casemate, the vertical buttress on the left proper of the port was bent; another vertical buttress 2 ft.

to the left was also bent. The second round was with the 451 lb. shot, which struck the 15 in. portion near the port-hole. More than half the shot remained fixed in the plate, plugging the indent, the centre of which was 3 ft. 11 in. from the granite base, the upper circumference of the shot being only 2 in. away from the upper edge of the plate. The metal here was split through, but there was no other fissure in the plate in direct connection with the shot-hole. Cracks extended in various directions, and at the rear considerable damage was done. The 450 lb. shot, in the third round, took effect on the upper portion of the proper left wing of the casemate, where it was 20 in. thick. It brought down two large pieces of the plate, which had been battered in previous experiments. The centre of the indent was 16 in. from the proper right edge of the covering plate, adjoining and in line with the upper part of the port, the shot-hole being plugged by more than half the shot, which remained in it. At the rear, the vertical buttress on the left of the port-hole was bulged and otherwise slightly damaged.

The striking velocities of the shot were as follows :—Round one, 1,360 ft. per second ; round two, 1,370 ft. ; and round three, 1,383 ft. The general effects upon the Plymouth casemate structure were very remarkable, in the flaking away of the thick face and covering plates, and in the bursting out of large portions of the rear planks and vertical struts. The first action of impact upon the front plates was to block out squarish areas by the extension of the old fissures of former rifle-shot wounds ; then the effect of the vibration of the layers of iron plates and planks against each other was to cast these blocked-out spaces to the front, a peeling action tending to the rapid distintegration of the iron wall. The results were highly satisfactory in establishing the valuable character of the metal of which the shotwere composed.

State Room Cars.—Much has been done for the comfort of night travelers, especially on our through lines to the West, and in the West. Only one of our roads—the Hudson River—is running upon every important day passenger train, a thoroughly luxurious car with really comfortable *arm-chairs*, as well as large and small compartments for private parties. This American type of first-class car has many advantages over the English type coming into use about New England.

New Works of the Chicago, Rock Island and Pacific Railroad.—These works are described in great detail in the Chicago "Railway Review." They are situated outside the southern limits of Chicago. The arrangement of the buildings is especially designed to save labor in handling material. They are built of brick with iron roofs. The machine shop is 336 ×112 ft., and 18 ft. high, with a wing 36× 50. One end is two stories high, with offices and drawing-room above, and offices, store-rooms, and tool-room, below. A longitudinal track runs through the middle, on one side of which are fifteen transverse tracks with drop tables; they are connected by a transfer table outside. The other side of the building is filled with Bement and Dougherty's tools, including three five-ton cranes, a double and a single wheel lathe, four radial drills, a quartering machine, an axle lathe, a 90 in. boring machine, a wheel boring machine, slotting, shaping and drilling machines, and lathes and planers in abundance. The boiler and smith shop is 344×80 ft.; the boiler end being 92 ft. long. It has a central railway track, and is provided with all the necessary tools. The smith shop has 36 fires and two steam hammers of 1,000 and 1,500 lb. each, and a scrap furnace. The Round House has an entire diameter of 278 ft.; the diameter of its inside space (turn-table in center, 23 ft. in diameter), is 158 ft.; the house part (roof pitching both ways), 60 ft.; containing 40 stalls; pits 40 ft. long; 12 ft. wide on the inner circle, from center to center of pier. The car shop is 252×80 ft., and 20 ft. high, in two stories, with a wing 200×80 ft. A foundry 130×60, with two wings 30×30 ft. is projected.

The entire cost of the works, thus far, is $550,000. The master mechanic is Mr. T. L. Twombly. The master car builder is Mr. J. L. Fogg.

The Ellershausen Process.—We have a very complete account of the rolling mill results of converting several kinds of iron by this process. Analyses are now being made, of the pig irons, ores, tap-cinders and puddle-bars. When they are completed, we shall publish the whole. The general result is a large loss of ore as compared with puddling, but an improvement of the iron, especially of a cold-short iron made from hematite ores, when treated with magnetic ores.

IRON AND STEEL NOTES.

Mining Produce of the World in Approximate Figures, expressed in German Cwts. By Prof. Tunner.

From the "Scientific American."

COUNTRIES.	Coal, cwt.	Iron, cwt.	Gold in mint pounds.	Silver in mint pounds.	Copper, cwt.	Lead, cwt.	Zinc, cwt.	Salt, cwt.
Great Britain	1,856,000,000	95,000,000	160	46,000	270,000	1,825,000	80,000	30,000,000
Austria	90,000,000	6,200,000	3,460	82,000	500,000	1,100,000	25,000	6,500,000
Prussia	420,000,000	14,500,000	5	46,000	53,600	45,300	1,250,000	4,000,000
Rest of Germany	40,000,000	5,000,000	50	71,000	4,000	24,000	......	3,500,000
France	222,000,000	27,500,000	250	25,000	35,000	45,000	10,000	7,000,000
Belgium	206,000,000	6,500,000	......	......	21,000	44,000	800,000	......
Russia and Poland	7,000,000	5,500,000	42,000	31,500	100,000	21,000	45,000	14,000,000
Sweden and Norway	300,000	3,000,000	8	45,000	45,000	11,000	......	......
Italy and Switzerland	2,000,000	900,000	250	2,200	6,500	11,000	......	4,500,000
Spain and Portugal	12,000,000	3,700,000	100	104,000	54,000	1,500,000	40,000	9,500,000
Turkey	500,000	300,000	1,600	......	12,000	......	......	1,000,000
America	350,000,000	22,000,000	192,000	2,400,000	400,000	300,000	100,000	(?)
Australia and other States	8,200,000	1,700,000	220,000	10,300	79,900	(?)	(?)	(?)
	3,214,000,000	191,800,000	459,883	2,863,000	1,581,000	4,926,300	2,350,000	80,000,000

James Russell and Sons Works, Wednesbury.—This extensive establishment is one of the oldest in Great Britain for the manufacture of gas, locomotive and other tubes. The concern dates back, indeed, to 1816; and Russell's first tube patent was taken out in 1824. A portion of the works is occupied in the manufacture of taper tubes, for telegraph posts in India. It has been found impracticable to use wood, as the insects destroy it rapidly. By means of novel and ingenious machinery, the taper tubes can be turned out as readily as if they weie of uniform diameter. A large quantity of small tubing is manufactured for bedstead stuff, and is consumed in the neighboring district. These tubes are cut into lengths, and are polished by being placed in a rotating cylinder for a length of time. The pieces of strip to be made into tubes are first subjected to the action of a bending machine (a crocodile, as it is not inaptly termed), and in this way they are roughly shaped. They are then put into a Siemens heating furnace, and when a welding temperature has been obtained, the iron is drawn through the proper molding apparatus, and becomes a perfectly welded tube. The hot tubes are next passed under huge slabs, and are speedily straightened. In this department there are seven Siemens furnaces in operation.

The boilers in these works are constructed entirely of tubes, secured together by a junction that allows of the removal of single tubes in a most expeditious manner. The water is forced through the system of tubes, and is thus made to pass over the fire 26 times. The whole arrangement is cased in a plate-iron chamber. It is impossible that any serious accident can happen from explosion with this multitubular boiler; for if a tube burst it is a matter of only trifling inconvenience, and the defect can be remedied in an hour. The boiler will evaporate 6 to 9 lb. of water with 1 lb. of small coal. This class of boiler only requires to be more generally known to be more extensively adopted, especially in confined situations, where an explosion would produce the most disastrous effects.

Another department of the works is devoted to the mannfacture of spiral coils for tuyeres, &c., and of connections of various kinds. A considerable area is occupied with furnaces for the manufacture of lapwelded locomotive tubes, which is a branch of the trade specially developed by this firm. There is nothing peculiar in the manipulation of these pipes, though, of course, more care is required in the manufacture, and a higher quality of strip is required. The pipes, when made, are all tested by steam and hydraulic pressure. The foundry department includes the manufacture of all kinds of brass cocks, taps and fittings required in connection with tubes. The screwing shops are necessarily very extensive, and here the latest improvements have been introduced for performing the operations in the most expeditious and economical manner. The double screw-machines are patented by the manager, and are a great advance upon the methods usually adopted. In connection with the welding of boiler tubes we ought to mention a double furnace that is in successful operation, the grate being so arranged that two sets of tubes can be heated and worked at the same time from the opposite ends of the furnace. The longest tube made in these works is 34 ft. 1 in.; the largest is 15 in. in diameter. The larger sizes of tubes are in some cases used for curious purposes, one application being for ordinary gate posts. The heaviest tubes made weigh as much as from 16 to 17 cwt. each. The extent of the operations carried on by this firm may be estimated from the fact that about 140 tons of finished iron are used up per week, and that the total length of tubing turned out per annum averages from six to eight million lineal feet. The works cover an extent of nearly four acres, and the number of people employed generally averages about 400. A short time ago the firm passed into the hands of a limited company, though the management remains substantially what it was previously. Mr. Joseph Smith is the general manager of the concern, and Mr. Lambton Brown the practical manager.—*Mining Journal.*

A Novelty in Blast-Furnace and Cupola Practice.—Messrs. L. Sibert, D. C. E. Brady, of Buffalo Forge, and J. D. Imboden and S. M. Barton, of Richmond, Virginia, U. S., have patented a new method of treating iron ores while in process of reduction in a blast-furnace, and of treating cast-iron in a cupola or other melting furnace for the production of steel or a superior quality of iron. It also relates to a method of treating the molten metal after it has left the blast or melting furnace, but while it is retained in a molten state, for the purpose of effecting a more complete purification. The first part of the invention relating to the treatment of the ore or iron in the reducing or melting furnace consists in the use of a flux composed of manganese and common salt with limestone or shells, such flux being introduced into the furnace to or with the ore or iron, and acting upon the ore or iron during and after its fusion and while subjected to the action of the blast to decarbonise it, and to cause the expulsion and carrying off of silicon, sulphur, phosphorus, and other impurities, and bring the iron to such a state that on its being simply cast into moulds it will have the character of cast-steel, and may be used for various purposes without further manipulation, or may be subjected to hammering and rolling to reduce it to bars for the manufacture of tools or other articles requiring hardness and temper.* The method of introducing the flux to the furnace may be the same as that of introducing any other flux, but in order to prevent the salt from sinking too rapidly through the furnace it is proposed generally to reduce it by water to a saturated solution, and to throw or sprinkle this solution upon the ore or pig or cast-iron, and allow or cause its water to evaporate before introducing the ore or metal to the furnace.† The fuel and ore or metal may then be introduced to the furnace in the usual manner, and the requisite quantities of manganese and limestone or shells introduced above each charge of ore, and the operation of reducing or melting be proceeded with in the usual manner. The quantity of the flux employed may be varied according to the quality of the ore or iron to be treated. In aid of the manganese, and to some extent as a substitute for it, there may be used iron ores of qualities containing large proportions of oxygen, and by such use of such ores or of crude metal more or less highly carbonised the fused mass may be operated upon to regulate and grade the quality of the metal produced. When the steel or refined iron thus produced is to be made by hammering or rolling, or both, into bars of suitable shape for the manufacture of tools or other articles, it may be run from the reducing or melting furnace into heated ingot moulds of cast-iron, and then covered with powdered manganese, and the moulds set in a heating furnace and kept at a uniform high heat, but not in a molten state, for several hours, or until the metal has parted with a portion of its carbon which is taken up by the oxygen in the manganese, and has become of a more steel-like character. The metal having been thus kept at a uniform high temperature for a long time is cooled slowly in the furnace, and in the process of crystallisation under these conditions the molecules arrange themselves in such relation that the metal after hammering and rolling possesses the flexibility and tenactity of cast-steel. When it is desired to give the metal a higher quality, resembling that of the better qualities of cast-steel, instead of running it from the reducing or melting furnace into ingot moulds as hereinbefore described, it is run into crucibles which are placed in a heating furnace, wherein it is kept in a molten state for several hours before casting into bars or ingots, or other forms, and about from 20 to 30 minutes before casting, there is introduced and stirred into it sulphate of magnesia in the proportion of about one part by weight to every 1000 parts of the metal.—*Mining Journal.*

* Fluxing with manganese and salt is not new, but the production of tool steel ingots from the blast-furnace by means of such fluxes would be a novelty indeed.—Ed. *V. N's Mag.*

† See Van Nostrand's Magazine, No. 2, page 142.

The Lurmann Improvement in Blast Furnaces.—The use of Lurmann's improved blast furnaces, with closed fronts, (introduced into this country by Mr. Asmus) is making rapid progress on both sides of the Atlantic. In Germany it finds universal adoption. Very satisfactory reports have been received from a number of charcoal, anthracite and coke furnaces in the United States. The claims of the inventor, seem in most cases to have been more than realized. The weekly production is increased fifteen per cent. and upwards ; while that which was formerly considered the most arduous portion of the labor at the furnaces is entirely abolished.

Among the establishments at which this patent cinder-block is now in operation, we may mention the Thomas Iron Works, Hockendouqua, Pa. ; Shoneberger, Blair & Co., Pittsburg ; Brady's Bend Iron Co., Pa. ; Carbon Iron Co., Parryville, Pa. ; Northampton Iron Co., Bethlehem, Pa. ; Sligo Furnace, Pa. (charcoal) ; Pennsylvania Furnace (charcoal) ; Muirkirk Furnace, Md., (charcoal) ; Cleveland Rolling Mill Co. ; Chicago Iron Co. ; and New Jersey Zinc Co., Newark, N. J.

In a few cases, the introduction of the new improvement has not been attended with satisfactory results ; but superintendents and workmen will hardly be able, in view of its universal success, to satisfy their employers that the fault is in the principle of the invention itself. It is not surprising that prejudice and private interests should in many cases delay the introduction of really beneficial improvements ; and on failure arising from such causes, we shall waste no words at present. We think it well, however, to warn American iron-masters against one of their own besetting sins, which, in the present instance, may lead to unnecessary disappointment.

In trying an invention like Lurmann's cinder-block, which has been already endorsed by experience, an iron-master, who is not yet familiar with it should follow strictly the directions of the inventor. One of the great difficulties with which this improvement has had to contend has been the itching desire of American metallurgists to vary it *before they had tried it.* Many are afraid that the cinder will not run through a hole so small as the drawings prescribe ; and they at once increase the bore of the cinder discharge, thereby materially lessening the advantages which it secures, by necesssitating a periodical stoppage of the blast. One inch and a half at the narrowest part is large enough diameter of cinder-discharge for the largest anthracite furnace. If these dimensions are exceeded, the blast soon follows the cinder with such force, that it must be turned off or slackened to allow the opening to be closed. We do not insist upon a continuous discharge of cinder, though Lurmann himself has obtained in this way the best results ; but we think both fairness and prudence should lead our furnace men to adhere to the proportions and constructions he proposes, until they have used them long enough to be certain they can better them.—*American Journal of Mining.*

Manufacture of Iron and Steel—new Processes.—Messrs. A. Ponsard and F. E. Boyenval, of Paris, have patented a peculiar process and furnace for manufacturing cast and wrought iron and steel whereby the costly blast-furnaces hitherto employed are dispensed with. The furnace is constructed similar to a reverberatory furnace, with a double sloping hearth for the collection of the molten metal. The hearth is heated either by an ordinary furnace, or by gas. Upon each of the sloping sides of the hearth rest the lower ends of a number of vertical fire-clay tubes or crucibles, without bottoms, such tubes entering at their upper ends with holes in the roof of the furnace, which roof is covered by a cast-iron plate, forming a platform, and being provided with moveable lids which fit over the mouths of the different springs leading down into the tubes. The ore, fluxes, and fuel are fed into the several tubes from the platform ; the flames circulating round the exteriors of the tubes effect the fusion of the ore without coming into contact therewith, the small amount of fuel contained inside the tubes along with the ore and flux, in order to effect the deoxidation of the ore and the carburation of the metal, should be of the best quality. It will thus be seen that two distinct kinds of fuel are employed—the ordinary fuel, for the purpose of fusion, and a superior fuel, of which only a small proportion is required. The molten cast-iron runs out of the bottoms of the vertical tubes and down the sloping sides of the hearth, and as fast as the contents of the tubes subside or descend fresh supplies of ore, fuel, and flux are added, thus rendering the process continuous. The molten metal is run off through a tapping hole in the side of the furnace, and the slag is removed through a separate opening from time to time as required.

In making wrought-iron the same apparatus is employed, and the wrought-iron is obtained direct from the ore. The ore employed should be first reduced to a metallic state, by subjecting it to an elevated temperature in a furnace in contact with the fuel. The ore thus reduced is introduced into the vertical fire-clay tubes, and the process continued as for the production of cast-iron, taking care, however, that no coal be mixed with the ore, which would in such case become carburated, the result being cast-iron or steel. In making steel the process is substantially the same as for cast or wrought-iron.—*Mining Journal.*

Production of large Homogeneous Masses of Wrought-Iron.—Some years since, the welding of two or more puddled balls into one, under a steam hammer, was practised in Wales, and, by this means, large masses were produced, but the process was not satisfactory, because the surfaces of the balls became oxidized, and good union could not always be secured between them in consequence. Puddled balls are now welded in the same way, both at Consett Iron Works, Durham, and on the continent of Europe, but the process is, in both cases, open to the objection we have just pointed out. Now, by welding the puddled balls together *in a furnace,* according to the invention of Mr. John Harris, of the Harefield Iron Works, Middlesex, and Mr. Vaughan Pendred, of London, (Editor of "the Engineer,") a perfect union is secured, because the iron at the time of welding is surrounded by a deoxidizing or neutral flame, caused to be present in the forging hearth by regulating the damper. The formation of scale is thus effectually prevented on the faces to be united ; the iron or steel, too, being maintained at a high temperature, the cinder or slag is kept fluid or lively, and may be the better expelled. Another advantage is that the cost of producing rails, armour-plates, etc., will thus be much reduced, because a mass of homogeneous iron or steel may be made at once of sufficient size to form a rail, armour-plate, or shaft, and the process of reheating, cutting, and piling, may, therefore, be dispensed with.

The machinery for effecting the process is fully illustrated in the "Mechanic's Magazine" of Feb. 26, 1869. Two horizontal steam hammers on opposite sides of a heating furnace, strike, through suitable openings, upon the masses within the furnace. A similar process for building up great guns was devised by Alonzo Hitchcock, an American Engineer, during the late war, and is illustrated on page 386 of "Ordnance and Armor." Gas welding in its various applications is considered by experts to be one of the most promising directions of improvement in iron construction. The results of Bertram's gas welding of boilers and girders is well known.

Curing Bad and Burned Steel.—A locksmith of Mulhouse, named Herrenschmidt, claims to have discovered a mixture which is said to give to the commonest steel the grain and the temper of the finest cast metal, and, moreover, to have the power of bringing back the original quality of steel which has been burnt. The mixture is composed as follows : With 16 litres of distilled water mix one kilogramme of hydrochloric acid, 19 grammes of nitric acid at 36 deg., 21 grammes of sulphate of zinc, and 100 grammes of tripoli. In this mixture is to be placed a piece of cast iron of the first fusion, weighing 100 grammes; when the acid mixture has acted on the iron for 24 hours, the composition is ready for use in the ordinary way, and it remains effective till it is all used.

Bessemer Steel in France.—The production of Bessemer steel last year in France was 42,601 tons; in this total rails figured for 25,760 tons.

Applying Hydrocarbons for Smelting.—The improvements in the use of hydrocarbonaceous fluids in combination with super-heated steam for the purpose of smelting, working of metals, etc., provisionally specified by Mr. Paul Rapsey Hodge, of London consist in the use of compound jets, wherein the steam and hydrocarbons are brought together at the same time in their proper equivalents to produce proper combustion. If for smelting or melting purposes for any of the metals, he inserts a compound jet in combination with, or in close proximity to, the tuyere holes or blast, so that the flame and heat arising from the combination of these two elements may unite and commingle with the other combustibles of the cupola, and reduce the "charge." He further proposes the use of these compound jets in the smelting, melting refining, or annealing of iron, brass, copper, lead, tin, silver, gold, ro any other metal, either in the cupola, reverberatory, or annealing furnace, or in furnaces wherein the metals are reduced or melted in pots. He uses the compound jets of hydrocarbon and steam in the heating and re-heating of metals for forging, welding, or brazing, as in the manufacture of iron or brass tubes, and by distributing these jets at such distances as will emit their flame to produce a uniform heat throughout the whole length of the furnace, such jets to be used either in combination with or without any other fuel. The compound jets are also applicable for the calcination of metalliferous ores, and for other purposes.—*Mining Journal.*

Utilizing Old Steel Rails and Rail Ends.—Mr. J. Thompson, of Stafford, England, has lately patented two improvements in this direction, both of which, however, have been previously practised in this country. His process is first, by dividing the rail, that is to say, passing it between rolls, so turned and arranged that they present V shaped projections to the heated metal passed between them, which has the effect of dividing the mass into many parts, which are afterwards rolled down into bars, &c. And, secondly, his improvements consist in so arranging his rolls that the thinner portions, such as the intermediate part of the top and bottom of a rail, shall be supported while the larger portions are reduced Thus by a series of rolls or grooves, a rail end may be first reduced to a flat mass, and then compressed or rolled edgeway, so that the middle portion shall be wrought and be subjected to the beneficial effects imparted by the processes, until the whole mass is reduced down to a bar of a suitable or desired form in its transverse section. In no case is the metal, while under operation, allowed to overlap, an effect he entirely avoids, as the description of metal named will not weld like ordinary iron or steel.

The Flexion of Iron and Steel.—The results of all the experiments on flexion are thus briefly summed up by Mr. Styffe, in his new work (reviewed on another page) on iron and steel:

1. Iron sustains at low temperatures a greater and at high temperatures a smaller load than at the ordinary temperature, before it obtains any perceptible permanent deflection.

2. The modulus of elasticity for steel and iron on flexion may, for practical purposes and without committing any considerable error, be generally assumed equal to that on traction. It is diminished by permanent deflection, but may be restored by heating, especially if raised to a red heat.

3. By hardening steel, its modulus of elasticity is diminished; but this diminution has not, in any of the hardened bars examined, amounted to more than about three per cent.

4. The elastic force of steel and iron on flexion, as on traction, is increased on reduction of temperature and diminished on elevation of temperature. The amount of this increase or decrease for a change of temperature equal to 1.8 deg. Fah. (1 deg. Cent.) does not, however, in general amount to more than 0.03 per cent, and apparently never rises to 0.05 per cent.

The Bessemer Steel Trade.—It is understood that Mr. Bessemer has signified his willingness to reduce his royalties from £2 to 2s. 6d. per ton, except for steel rails, for which a rebate of 20s. per ton is already allowed. Ordinary Bessemer steel will thus be reduced nearly £2 per ton, and rails about £1 10s. This will remove all inducements which might otherwise exist to infringe the patent-rights remaining to Mr. Bessemer after the expiry of his principal patents in the course of next year, and at the same time will give an impetus to the steel rail trade, by permitting the steel rails to be sold in the market at a price but little higher than that of iron. If the Heaton process should solve the question of converting *cheap* pig iron into steel, iron rails may, probably, be entirely displaced.—*Mining Journal.*

ORDNANCE AND NAVAL NOTES.

Comparison between Polygonal and Studded Projectiles.—Under the above heading we have a very suggestive paper from the pen of Mr. Joseph Whitworth. In this paper Whitworth projectiles cast with rifled polygonal surfaces are compared with Woolwich projectiles, with dove-tailed recesses for the insertion of soft metal studs to give rotation. The subject is treated under three heads.

1. *Simplicity and Economy of Production*—Polygonal.—Projectiles for field guns are fired as they are cast, just as in the case of smooth bores. For large guns, they are planed or shaped, one machine only being required. The time occupied in rifling a 9-inch shell, weighing 300 lb., is only twelve minutes. In studded projectiles the body of the shot has to be cast with recesses for the studs, or they have to be drilled in, and recessed with cutters. In either case these recesses are a source of weakness, rendering the shell liable to break up in the bore of the gun. The 9-inch projectile has 12 studs inserted in it, by pressure, each one requiring attention; there are also six different surfaces to attend to, viz: The body of the shot, the outer circumferences of the studs, the right and left sides of the rear studs, and the right and left sides of the front studs, which are made narrower than the rear studs, on account of the increasing pitch. The projectile for field guns has six brass studs fitted into it.

Studded projectiles have in their manufacture to pass through several workmen's hands, and costly machines have to be employed, viz: lathes or grinding machines, drilling and punching machines, in addition to the rifling machines. The cost of wages for the large projectiles is many times greater than for those of the polygonal system; the cost of the metal for studs is also considerable; and to this must be added the cost of a packing case or thick canvass bag for each projectile, on account of the soft metal studs being liable to injury if one projectile is allowed to rest upon or knock against another. In the penetration of armour plates the studs are an obstruction, and the power required to shear them off is so much deducted from the force of the projectile.

2. *Area of Bearing Surfaces.*—For a 9-inch polygonal projectile, the rifled surfaces which both support and rotate the shot have an area of 187 in. The 12 studs of a 9-inch Palliser projectile have a circumferential area of 18 in. for supporting the shot, but the area of the sides of the six rear studs, by which the rotary motion is given, is only 1-6 in. No practical engineer would think of providing so small a surface to give even a small amount of rotation to a body weighing 250 lb., much less when the rotation of the shot at the muzzle of the gun has to be at the rate of about 2,400 revolutions per minute. The increasing pitch which has been adopted prevents the use of more than one stud in each groove for giving rotation. This varying curve is the worst possible mode of imparting rotation, for each rear stud can only bear against the side of the groove of the gun on a line of its surface, on account of the ever varying curve, except by excessive pressure, which jams and distorts the soft metal, and occasions liability to accident. The greater the amount of windage, the greater will be the liability to accident.

3. *Centring of the Shot in the Bore.*—In starting, the polygonal projectile centres itself, so that its axis coincides with the axis of the gun, and it is propelled through the bore with a steady equable motion. The studded projectile in starting does not rise and centre itself parallel with the axis of the bore, but lies on the bottom; consequently, the gases and unconsumed powder pass over the projectile, causing excessive scoring, and tending to keep the shot down, thus giving increased pressure to the outer surfaces of the studs, particularly those of the rear, and adding to the irregular and vibratory motion as it is propelled through the bore, and the greater the windage, the more unsteady will be the motion.

Field Artillery.—With respect to field artillery, but few important changes occurred in the course of last year. For the most part the systems adopted have merely been developed and carried out. England alone has adopted a new plan by abandoning the breech-loading Armstrongs for the muzzle-loading seven, eight and nine-pounders of Whitsworth. The smooth-bore has been almost universally abandoned except by America, which retains smooth-bore twelve-pounders, and perhaps by Spain. Northern and Southern Germany have the same system and caliber breech-loading four and six-pounders. Belgium most closely resembles them in this respect. Revolving cannon, mitrailleuses, and other similar instruments have been almost universally experimented upon, with excellent results as far as short and middle distances are concerned. Great value is attributed to them in the defence of defiles and trenches, but they have been nowhere adopted except in France, where they are to be used in the field. With regard to heavy artillery, the chief interest is excited by the question of iron plating. After the English experiments it may be considered as certain that the smooth-bore used in America, in spite of any possible increase of caliber, is inferior to the rifle-bore in its effect on such armour. The English experiments on plated land fortresses were highly interesting, as they show that, under favorable circumstances, twelve-pounders are equal to attacking the strongest plating. At present the sides of ships covered with eight or nine inch plates, like those of the English Hercules, are no protection against the heavy artillery now on trial. While the English tubes are formed of wrought iron, France and Sweden use cast iron, and Prussia, Russia and Belgium, cast steel. As material for projectiles use is made of cast steel and hard cast iron prepared in England by Palliser, and in Germany by Gruson. That cast in Germany most closely approaches cast steel, as the balls made of it penetrate the plating without being broken, as those of Palliser are. The chief advantage of hard cast iron is its great cheapness when compared with steel. An important problem with respect to siege trains, and those intended for the defence of fortifications, is the placing of the guns behind earthworks, so that the men that serve them may be covered without the range being obstructed or narrowed. The Prussian system is inferior to the English one in this respect, but Mr. Moncrief attains his end by means of a complex mechanical arrangement, and at a far greater expense. The prismatic powder is now much used for heavy artillery. In conclusion, attention is called to the fact that, in spite of all activity and all endeavors after perfection, we are still far from having brought the matter to a definite conclusion. It is true that time and circumstance often force us to make a choice, but we have not yet attained a point from which the end can be seen.—*Kreutz-Zeitung.*

The English Guns and Gun Factory.—Englishmen have reason to be proud of Woolwich as it now is, grumblingly as they may pay the bills which the great national arsenal involves. There is there that high order of engineering thought, engrafted upon Sir William Armstrong's best but not always useful thoughts, of which all Englishmen may congratulate themselves. There is the highest order of skill, perfected by the longer, steadier, more sober training, of which we may justly boast as a nation, when compared with other industrial nations. To see old cast iron guns puddled into good bars, to see them welded up to lengths of from 150 ft. to even 270 ft., to see these heated in a heating furnace 190 ft. long, with, in some cases, 80 ft. of the bar projecting beyond the rear end, to see these coiled on a coiling mandril, to see two or even three of these coils wound upon each other, to see these solidly welded into a single block, a block which, for the new 25 ton guns, weighs, in its rough state, upwards of 25 tons, all this is a sight to see. It is wonderful to a forgeman—to any worker in iron—to see these blocks brought out perfectly sound, turned in lathes weighing 84 tons, and swung bodily into other lathes, formed for turning the trunnions. It is something to see these guns reduced 7 in. in diameter at a single cut, something to see their steel tubes bored out of the solid, in segmental chips of $\frac{1}{8}$ in. feed, $5\frac{1}{2}$ in. radius, something to feel or to shrink from feeling the heat generated in boring, notwithstanding the stream of cold water so freely admitted; a stream almost large enough for the abundant supply of many a country village—all this is something, but it is much more to know, as we do know, that the guns thus made, costly although they may be, are indisputably the *best* guns for naval service known to ordnance engineers of the present century. —*Engineering.*

Armour *vs.* Speed.—"As it has proved impossible to invent a plating absolutely impervious to guns of a high caliber, some have lately begun to question the relative advantages of a defense, the value of which depends on distance. Hence many States have commenced building very swift vessels of wood, which are to be armed with heavy guns, and to carry a larger supply of coal instead of armour, and these may be very useful in conjunction with the iron-clads for the protection of the merchant navy, though they cannot supercede the latter in the line of battle, or the protection of the coasts. America has lately built the Wampanoag, a vessel of great speed, and England is now fitting up on similar principles the Inconstant, a frigate lately launched at Pembroke. In order to obtain great speed, the chief advantage proposed, Reed has given the frigate an exceedingly light and slender form. Two smaller vessels, the Volage and the Active, each of 2,322 tons burden and 600 horse-power, are now being built at the docks of Blackwall on similar principles. The Spartan, of 6 guns, lately launched at Deptford, is still smaller, and its superiority lies in the small quantity of coal consumed. The Sirius, a wooden corvette, which is intended to supply the place of those formerly in use in hot climates, is a vessel of six guns, 1,268 tons burden, and 350 nominal horse-power, constructed by Reed, and furnished with very healthy cabins and berths, and excellent ventilation. Even if these vessels should satisfy all the expectations formed of them, they would not, as we have already said, supercede the iron-clads, and Dupuys de Lôme in France, and Coles and Reed in England, rival each other in ingenious endeavors to perfect the construction of the latter."—*Staats Anzeiger.*

Resignation of M. Dupuy de Lôme — The French Navy.—In the French naval world the news of the day is the resignation of the Chief Constructor of the Fleet, M. Dupuy de Lôme, who has thrown up his office and gone to canvass a seaboard constituency. It is presumed that he could not get on with the present First Lord, Rigault de Genouilly. Most of the large wooden screw vessels, and all the iron-clads, with the exception of the Couronne and a few floating batteries built by Lemoine, were constructed by M. Dupuy de Lôme. The resignation is kept dark, as there is no naval architect to replace the engineer who applied steam to the navy when he built the Napoleon, and plates to frigates when he built La Gloire. The state of the French fleet for the present year is thus set down: Ships, 2; frigates, 19; corvettes, 9; coast-guards, 7; floating batteries, 26—total, 63 iron-clads. Of screws there are 241, or 15 ships, 10 frigates, 21 corvettes, 60 avisos, 70 gunboats, 35 transports and 2 specials. To this force must be added 51 paddle-wheelers and 100 sailing vessels. Of the iron-clads we may remark, that the two ships, the Magenta and Solferino, are not so large, and are by no means such formidable vessels as the largest type of frigate, represented by the Ocean, which is now ready for sea. M. Dupuy de Lôme designed five of these frigates before leaving office —the Friedland, Marengo and Suffren, laid down a couple of years ago, and the Richelieu hardly commenced. The Ocean will carry more guns than the Magenta, and she is more thickly plated; besides this, she has four fixed turrets on each corner of her central battery, each armed with an 11-inch gun. The Minister of Marine, when he defends his budget next week, will perhaps furnish some details respecting his department. — *Army and Navy Gazette.*

Details of the American Navy.—Mr. Ford, the Secretary of our Legation at Washington, in his report to the foreign office, dated 31st December last, states that the cost of the navy during the past year was £3,656,066, the total number of vessels of all sorts being 206. The following table shows its character:

	No.	Guns.
Ironclads	52	129
Screw steamers...........	95	938
Paddle-wheel ditto........	28	199
Sailing vessels...........	31	477
Total...............	206	1743

It will be seen that the American ironclads carry an average of only two and a quarter guns. The European squadron includes five vessels: the Asiatic, nine vessels; the North Atlantic, six vessels; the South Atlantic, five vessels; the North Pacific, eight vessels; and the South Pacific, six vessels. The net proceeds of the prizes captured during the late war had been adjudicated at the large amount of £3,151,720. The list of the officers shows a great absence of the ornamental class; it includes one admiral; one vice-admiral, and only ten rear-admirals. There are 302 engineers, 20 chaplains, 11 professors of mathematics, 5 naval constructors, 5 assistant-constructors, and 5 civil engineers. Mr. Ford states that the Secretary of the Navy calls attention to the fact that in none of the navy yards of the United States is there more than a single dry dock, and that there are but six in the whole country—a deficiency which would be seriously felt in the event of a maritime war. He adds that the docks at Cherbourg and Toulon, in France, and at Portsmouth, in Great Britain, each contain a greater number of dry docks than all the United States' dockyards combined; and that whilst Great Britain, France, and other maritime powers are increasing their dry dock facilities, nothing in a similar direction is being done in the United States.—*Engineer.*

Railway Education for Soldiers.—It is now proposed, though not for the first time, to teach the soldiers of France how to run a railway, in view of the new and important function of railways in warfare. Says a Paris correspondent of the "Engineer": The Minister of War and the Minister of Marines have applied to the great railway companies to arrange for the instruction of the military engineer corps in the work of laying down and keeping in order iron ways which may become necessary in case of war, and also in the stoking and managing of locomotives. The companies are said to have expressed their readiness to do all in their power to carry out such measures, considering that it would be greatly to their interest to have a body of disciplined and intelligent men instructed in such duties, and from which hereafter they may obtain engine drivers, stokers, and other servants and officers.

Moveable Harbor Obstructions.—A subject under consideration by the French naval authorities, is the defence of maritime ports without obstructing the way; several plans have been proposed in the case of Toulon, but none have been considered satisfactory, and a new project is now put forward, which consists in the establishment of a floating stockade, which can be laid across the entrance of the port or withdrawn in a few hours, and which at the same time shall be sufficiently strong to withstand the full force of a steam squadron, and thus guarantee the port from all chances of sudden attack. The problem is not a very easy one to solve, except at a considerable cost, and we shall see whether the military and civil engineers will hit upon a solution of it.—*Cor. Engineer.*

Italian Iron-Clads.—From a recent report of the Italian Navy Minister it appears that during the year 1868 three iron-clads were completed in the Italian dockyards. These vessels were the Venezia, a frigate; the Caracciolo, a corvette; and the Alfredo Cappellini, a gunboat. Their aggregate tonnage was 8,000, their steam power 1,270. Four other iron-clads were in course of construction at the end of the year 1868, and the works were being pushed forward with great activity. Italy is now building her war vessels in her own dockyards, and fitting them for sea without foreign assistance, except in the case of the guns, which are of the Armstrong pattern, and which have accordingly to be obtained from England.

Proof of U. S. Guns—Error Corrected.—In the last number of this Magazine, we copied an item from the "Philadelphia Inquirer" on the cost of heavy guns, in which it was stated that "from the spring of 1864, all 15-inch guns procured at Pittsburgh were taken without any powder proof, according to an order from the Chief of Ordnance." This statement, we now learn officially, is not correct. Every 15-inch gun, and indeed every gun procured by the ordnance department at Pittsburgh was subjected to the powder proof before being taken. And the Chief of Ordnance never accepted or authorized the removal of any guns from any one of the foundries before it was fired.

Soft Armour Plates.—The results obtained last summer on the trials of the "Millwall Shield" and "War Office Casement," as compared with the late results against the "Plymouth Fort" section, seem to have settled the question for ever as to the relative advantages of soft and hard iron plates for resisting shot. In the former trials the plates were soft and copper-like, and there was scarce a case of a crack, although the plates were hit much harder, while the result upon the hard plates of the Plymouth Fort were fearfully great, even against the twentieth portion of the target.—*Army and Navy Gazette.*

The Forty-Ton Gun.—Preparations are making at the Royal Gun factories for the manufacture of the 40-ton gun, some time ago designed by Mr. Fraser. Of the 25-ton 11 in. guns, a good number are already completed.

A New Rifle, the invention of Meyhöfer, in East Prussia, is said to be capable of discharging thirty shots a minute, and of killing at 1800 paces.

RAILWAY NOTES.

The First Locomotive.—Pen-y-darran, Wales, is chiefly remarkable for its connection with the first tramway—for which an act of Parliament was obtained in 1803 for the first locomotive ever tried,—and with the able inventor, Trevethick, who there made his first essay. The first run of the locomotive occurred in February, 1804. Previously there had been a whisper in the scientific world of the use of steam and of its employment in propelling vehicles, and abortive attempts having been frequent. Samuel Homfray by some means was brought into connection with Trevethick, and the result was that this able but ecentric man visited Merthyr, and in conjunction with a self-taught mechanic, one Rees Jones, whose homely portrait can be seen in the Kensington Museum, began to build his locomotive. Building is not an inappropriate word in this case, for the stack was actually built up of bricks the same as an ordinary chimney, and the whole affair was peculiarly odd. The stack was tall and clumsy, the body dwarfed, perched on a high framework, so as to approximate to the spider fashion; the cylinder, in addition, was upright; the piston worked downwards, and at every revolution of the wheels there was a monstrous clang produced which, heard nowadays with the asthmatic puffs of steam, would provoke the gravest mechanician to laughter. When completed, Homfray introduced his friend Richard Crawshay to the novelty, doubtless much to that individual's amusement, certainly to his incredulity as to its being fit for anything, for he readily accepted a wager with Homfray for £1,000, maintaining that it would not convey a load of iron from Pen-y-darran to the navigation—a distance of nine miles. The eventful day arrived for the trial, and never had there been so much excitement. The sturdy Englishmen were there, and natives from every Welsh county lined the road, and mounted every eminence that commanded the tramway; and when Trevethick jumped on his iron steed, and began slowly to move onwards amidst clanging iron and puffing steam, the uproar was terrific. By the arrangements made no one was allowed to assist the dauntless Cornishman and for a time he did not seem to want it. Surrounded by a host, he passed down the valley, making about five miles per hour when a sad misfortunate happened,—the clumsy stack came in contact with a bridge and was ruined! Trevethick stood for a moment among his bricks, but only a moment. Fertile in resource, he was soon steaming onward again, and not only conveyed his load of iron to the navigation, but a crowd of exultant passengers along with it, who to their latest day prided themselves on their glorious ride. It was fortunate for Homfray that the wager was a loose one. The iron was taken down and the bet won; but Trevethick failed to bring his empty trains back, and for some time the new invention as a mode of transport remained in abeyance.—*Engineer.*

WORKING EXPENSES OF BRITISH RAILWAYS.

Mr. Forbes, general manager of the London, Chatham and Dover railway, has furnished to the "Railway News" the following very complete comparative statement of working expenses on twelve of the principal railways of the United Kingdom, for the half-year ending December, 1868.

	LON., CHATHAM & DOVER.			SOUTH EASTERN.			LON., BRIGHTON & SOUTH COAST.			LON. & SOUTH WESTERN.			GREAT NORTHERN.			LON. & NORTH WESTERN.		
	1,167,211 train miles, 143½ length of line.			2,004,703 train miles, 336½ length of line.			2,095,506 train miles, 312½ length of line.			3,008,226 train miles, 604½ length of line.			4,346,768 train miles, 507 length of line.			11,461,870 train miles, 1,416½ length of line.		
	Amount	Rate per train mile.	Rate per ct. on receipts.	Amount	Rate per train mile.	Rate per ct. on receipts.	Amount	Rate per train mile.	Rate per ct. on receipts.	Amount	Rate per train mile.	Rate per ct on receipts.	Amount	Rate per train mile.	Rate per ct. on receipts.	Amount	Rate per train mile.	Rate per ct. on receipts.
	£	d.	£	£	d.	£	£	d.	£	£	d.	£	£	d.	£	£	d.	£
Maintenance and renewals	33,335	6.89	10.75	59,564	7.13	8.00	54,416	6.23	7.99	100,979	8.05	12.84	104,254	5.76	9.17	305,111	6.38	8.89
Locomotive expenses	42,145	8.49	13.59	78,722	9.42	10.57	*92,394	10.58	13.57	101,209	8.07	12.87	161,418	8.90	14.19	392,069	8.20	11.42
Carriage and wagon expenses	14,922	3.06	4.80	21,266	2.54	2.85	21,861	2.53	3.21	29,984	2.39	3.81	48,855	2.69	4.29	129,180	2.70	3.71
Traffic expenses	53,109	10.92	17.12	103,135	12.34	13.85	94,419	11.38	13.87	134,914	10.76	17.16	155,370	8.58	13.66	496,672	10.39	14.49
General charges	10,017	2.21	3.46	23,431	2.80	3.14	13,697	1.52	2.01	17,960	1.42	2.27	26,105	1.44	2.29	57,976	1.12	1.68
Compensation	3,034	0.63	0.97	5,068	0.60	0.68	3,897	0.44	0.57	5,838	0.46	0.74	29,974	1.65	2.63	64,997	1.36	1.89
Legal expenses	4,494	0.92	1.47	4,691	0.56	0.63	8,184	0.93	1.20	2,438	0.19	0.31	3,501	0.19	0.30	8,660	0.18	0.25
Rent										558	0.04	0.07						
Rates and taxes	12,123	2.49	3.91	31,942	4.18	4.69	29,589	3.38	4.34	18,829	1.50	2.39	20,221	1.12	1.77	53,974	1.16	1.57
Passenger duty	6,934	1.42	2.23	18,166	2.17	2.44	17,268	1.97	2.53	19,383	1.54	2.46	15,191	0.84	1.33	45,293	0.94	1.32
Tolls to other companies				1,400	0.16	0.18	†533	0.06	0.08	1,775	0.14	0.22				13,011	0.27	0.37
Parliamentary expenses	2,000	0.41	0.64				972	0.11	0.14	3,951	0.31	0.50	1,161	0.09	0.14	25,000	0.52	0.72
	182,843	37.44	58.94	350,385	41.90	47.03	337,230	39.13	49.51	437,791	31.87	55.64	566,550	31.26	49.77	1,591,943	33.22	46.31
Maintenance and renewals p. mile	£232.29			£177.01			£174.13			£167.04			£205.62			£215.39		

	GREAT EASTERN.			MIDLAND.			MAN., SHEFF. & LINCOLNSHIRE.			NORTH STAFFORDSHIRE.			METROPOLITAN.			NORTH LONDON.		
	3,657,928 train miles, 803¼ length of line.			7,248,104 train miles, 849 length of line.			2,402,722 train miles, 258¾ length of line.			614,479 train miles, 158 length of line.			350,472 train miles, 10 length of line.			517,827 train miles, 11½ length of line.		
	Amount	Rate per train mile.	Rate per ct. on receipts.	Amount	Rate per train mile.	Rate per ct. on receipts.	Amount	Rate per train mile.	Rate per ct. on receipts.	Amount	Rate per train mile.	Rate per ct. on receipts.	Amount	Rate per train mile.	Rate per ct. on receipts.	Amount	Rate per train mile.	Rate per ct. on receipts.
	£	d.	£	£	d.	£	£	d.	£	£	d.	£	£	d.	£	£	d.	£
Maintenance and renewals	89,674	5.89	8.64	131,960	4.46	8.02	39,084	3.90	7.34	19,705	7.69	11.08	5,190	3.55	3.33	8,253	3.82	6.01
Locomotive expenses	148,973	9.77	14.32	244,656	8.10	14.55	52,349	5.22	9.83	21,755	8.49	12.23	14,802	10.13	9.49	33,042	15.31	19.37
Carriage and wagon expenses	46,786	3.07	4.50	56,518	1.87	3.36	19,531	1.95	3.67	13,174	5.14	7.40	2,500	1.71	1.60	8,700	4.03	6.27
Traffic expenses	158,351	10.39	15.23	264,205	8.71	15.71	73,384	7.33	13.79	26,555	10.37	14.93	12,336	8.44	7.93	25,084	11.62	14.70
General charges	21,661	1.42	2.08	25,857	0.85	1.53	12,666	1.26	2.38	5,741	2.07	3.22	5,490	3.75	3.52	3,688	1.51	2.16
Compensation	10,507	0.68	1.01	30,425	1.00	1.81	3,631	0.32	0.56	210	0.08	0.12	769	0.52	0.48	1,383	0.64	0.80
Legal expenses	6,639	0.43	0.63	3,934	0.12	0.23	3,072	0.36	0.57	3,915	1.43	2.22				251	0.11	0.15
Rent							8,849	0.88	1.66	191	0.07	0.10						
Rates and taxes	22,647	0.82	2.17	30,673	1.01	1.82	9,222	0.92	1.73	2,190	0.85	1.23	8,097	5.54	5.19	4,912	2.27	2.88
Passenger duty	17,412	1.14	1.67	16,369	0.54	0.97	3,764	0.37	0.70	1,509	0.51	0.73	4,644	3.17	2.97	2,633	1.22	1.66
Tolls to other companies							3,887	0.38	0.73				3,683	2.52	2.36			
Parliamentary expenses	3,166	0.20	0.30	1,872	0.06	0.11	688	0.06	0.13	‡	‡	‡						
	525,816	33.81	50.55	809,469	26.75	48.11	229,530	22.95	43.09	94,748	36.70	53.26	57,511	39.33	36.87	87,946	40.53	54.00
Maintenance and renewals p. mile	£111.63			£158.96			£151.04			£124.71			£519.09			£717.65		

* Includes £9,362 for new engines and tenders. † After deducting tolls received. ‡ Included in legal expenses.

GERMAN ASSOCIATION OF RAILWAY ENGINEERS.—Some years ago, all the German railway companies joined in a kind of association called "*die Techniker, Versanvurg des Vereins deutscher Eisenbahn Vervaltungen*," with the object of bringing the experience of their respective railways into use to their mutual benefit. A technical commission of about fifty members was selected from amongst the most eminent men from the different divisions of a railway administration. In 1865 a general meeting was held at Dresden, when it was decided that the long period of seven to eight years between each general meeting should be shortened to two years, and the next general meeting was fixed for 1867, but on account of the war did not take place till 1868—at Murich. Of the sixty-eight different railways belonging to the association, there were no less than fifty then represented, generally by the director-general and the chief engineer.

The advantage of these general meetings is, that the technical commission had brought together all the experience gained on the respective railways up to the present day, and answered all the questions which at the former meeting were proposed for discussion. Of the questions twenty-two related to the permanent way department, twenty-six to the engine and rolling stock, and fifteen to the traffic department. On all these questions each railway company had given their experience, and the technical commission had from these facts made a *résumé* in answer to each question and published a large volume with tables as a "referate," given to each member. At the general meeting each question was read, as well as the *résumé* in answer to it, and if no objections were made by any of the members it was passed, as decided upon by the general meeting.

At the meeting at Dresden again there were formed different sections to discuss the different questions where members of each of these branches could more thoroughly discuss the matter without unnecessarily occupying their fellow-workmen's time, as was the case, when all the questions were treated together. It is only just to the technical commission to acknowledge the great accuracy, care, and skill by which all the questions have been treated. Indeed, we are told that the commission had had thirty meetings to investigate all the statements from the railways, and draw from them a *résumé*.

THE PROGRESS OF THE NARROW GAUGE IN GREAT BRITAIN.—The Great Western Railway has always played a prominent part in the annals of British railways. Its career in connection with the broad gauge is one of considerable importance, and its struggles with powerful competitors in the interest of the narrow gauge will not soon be forgotten. It stretches its giant arms to Exeter and South Wales in one direction, and to Birmingham and Liverpool in another; and in spite of every obstacle, it presses the London and North Western hard, as the greatest British railway. But at a time when it has attanied an importance of which its early promoters never dreamt, even in their most sanguine moods, the Great Western appears to be abandoning its first love, and to be gradually likening itself to other British railways *by reducing its gauge to the width generally adopted.* The whole of what is known as the northern division of the Great Western has now become narrow gauge; and, although the broad gauge still stretches westward as far as Exeter and Truro, it is probably doomed for good and all, and *will disappear altogether as years roll on.* It is with railways as with individuals—a policy of eccentricity and isolation does not pay, and the railway which cannot send its trucks all over the empire, if need be, is sure to command but a feeble traffic; and to yield meagre dividends. —*London Colliery Guardian.*

BRITISH AND PRUSSIAN RAILWAY STATISTICS COMPARED.—The *Staats Anzeiger* contains a comparison of the railway traffic of Great Britain and that of all the provinces of Prussia for the year 1867, according to which there was one Prussian mile of railway to every 1.9 Prussian square mile in Great Britain, and for every 5.3 sq. miles in Prussia. The capital invested averaged 1,100,198 thalers per Prussian mile in the United Kingdom, and 549,975 thalers in Prussia. In the former State 2.8 locomotives and 90.16 carriages, and in the latter 2.4 locomotives and 122.6 carriages were employed for every mile of rail. In Great Britain 17,338 trains run daily; in Prussia only 6,586, but the distances traversed by the latter were far greater. In Great Britain 287,807,904, and in Prussia 38,766,866 persons were conveyed. In the former State the expenses amounted to 43,001 thalers, and the receipts to 86,480 thlrs., and in the latter to 43,091 and 78,813 thalers per mile. The expenses are as follows: In the United Kingdom, for management of the line, 19 per cent transport 62, general management 18.3; in Prussia they were 32.6, 61.4 and 6 per cent. The paid up capital averaged in Great Britain 3.91, and in the Prussian private lines 5.98 per cent.

THE PACIFIC RAILWAY.—Mr. Dilke, in "Great Britain," says: The discovery that it was practicable to carry a railway over the Rocky Mountains, within American territory, fell almost as heavy on the hopes of the Canadians as the discovery of the route by the Indies to the Cape lighted on the old prosperity of Venice. Of all the marvels of American energy, of all the triumphs of rough and ready engineering, the Pacific Railway is perhaps the most marvellous and most triumphant. They say the rails can be laid at the rate of nine yards in fifteen seconds, and the workmen have to cross their hands while the 300 or 400 tons of iron are brought up day by day to the front. The works are carried on in an enemy's country, and the advanced carriages of the construction train are well supplied with rifles hung from the roof.

THE CENTRAL RAIL SYSYEM.—An experiment has been made on the road between Roanne and Charlieu, with a modified kind of mountain railway; a pair of rails about a mile in length was laid down by the side of the road, following all its irregularities, a central rail being added in those parts where the gradients were unusually steep, and the engine provided with horizontal wheels, which nipped this central rail. The report of the trial is but meager; but it is asserted that the engine, to which were attached three ballast trucks, worked admirably, going up and down the inclines with ease, not only with the aid of the horizontal wheels, but by means of these alone, the ordinary driving wheels being thrown out of gear.

Railway Traveling in India.—A correspondent of the Times writing from Umballa says: "As a striking illustration of the changes being wrought by railways in India, it may be recorded that I traveled from Calcutta to Umballa in 41 hours, including stoppages, by the special train which preceded the Governor-General's, spent 24 hours there, and returned by the ordinary express train in 52 hours—a distance of 1154 miles, or 2308 both ways. The sleeping carriages enable the traveler to undertake such a continuous journey with comparatively little fatigue ; but the dust and dirt, who shall describe? The cost, first-class, is about £12 each way a servant. Dinner at refreshment-rooms, better than those of England, cost 6s. 3d., with a quart of Ind Coope and American ice *ad lib.*"

Safety Device for Car Axles.—A new device for preventing serious results from the brakeage of axles when in motion, has been lately applied on the Providence and Worcester Railway. When first applied, it consisted of a wrought iron sleeve surrounding the axle, and extending from wheel to wheel, the sleeve being applied in halves, and firmly clamped together and to the safety-beam of the truck-frame. Now, in addition to the sleeve, the rims of the wheels are capped over with strong iron shields, which are bolted to the safety-beam and to the frame of the truck at the side, and fore and aft, so that the wheels and axle are pretty securely caged.—*Cor. Railway Times.*

Wooden Wheels.—The directors of the New York and New Haven Railroad have decided to try an experiment in the use of wooden wheels on the cars upon their road. Quite a number of the wooden wheels have been purchased, and they will be substituted for the present iron ones on some of the new cars. They are understood to cost nearly trebble the price of iron wheels, but are considered quite as cheap in the end. They are made of elm or teak wood, and bound with steel tires. In addition to being less liable to break by the action of frost or otherwise, they make less noise.

George Hudson, the English "ex-railway king," is now in France in an utterly destitute state. A movement was on foot to induce the North-Eastern Railway company to grant him an annuity of £200 a year. Little more than twenty years ago Mr. Hudson (who had previously been a retail dry-goods merchant in a small town) was the most conspicuous man in England, and the titled personages of the land had often to wait for an audience with him.

NEW BOOKS.

The Mines of the West—A Report to the Secretary of the Treasury. By Rossiter W. Raymond, Ph. D., Commissioner of Mining Statistics. J. B. Ford & Company, 39 Park Row, New York.

Congress made a wise move when it appointed Dr. Raymond Commissioner of Mining Statistics, as his preliminary report now before us amply proves. The appointment of scientific experts to positions of this character cannot be too strongly recommended, and while Dr. Raymond's predecessor, J. Ross Browne, did a great work and did it well, still the work which the present commissioner is required to carry on could only be thoroughly accomplished by a scientific man. This will be evident from the letter of instructions furnished by the Secretary of the Treasury, of which the following are the principal points. The most important subjects for inquiry at present seem to be—

First. As to the different processes of treating the ores, their chemical combinations, and the system demonstrated by practical experience to be the most successful.

Second. The relative merits of the various invention machines and mechanical contrivances now in use or projected for the reduction of the precious metals, and for all other purposes connected with the business of mining and metallurgy.

Third. The special needs of the great mining interest; how it can be encouraged and rendered most productive ; how far individual enterprise should be left untrammelled by legislative action, and to what extent and in what instances government might properly lend its aid to facilitate the development of the mines and thus arrest the present annual decrease of the production of bullion.

Fourth. What has been the experience of other countries resulting from the establishment of national institutions for the education of miners, and how far would the systems prevailing in Europe be applicable to our people or appropriate under our government?

In view of the great and increasing importance of our mineral wealth, the weight of the questions here propounded and their intelligent discussion will be evident to all.

Mr. Raymond in his reply to the Secretary of the Treasury, states: "I have not attempted to make it (my report) comprehensive, at the cost of accuracy. It contains my observations and such others as I have collected from perfectly trustworthy sources. The report is in two parts, the first containing such observations of the present condition of our mining industry as I could collect, and the second discussing at considerable length the subjects involved in the relation of the government to that industry. The subject of methods and processes of mining and reduction I have entirely postponed, proposing to treat it in my next report with more care and thoroughness than would have been possible in the brief period and with the limited means at my disposal last year." The report is well and lucidly written, the style excellent, technical or obscure terms are avoided. The report is embellished with profiles taken *on the plane of the view*, which will be found to help very materially in the proper understanding of the subjects discussed. The bullion product for the past year, (1868,) is made to be as follows from official returns and estimates:

California	$22,000,000
Nevada	14,000,000
Montana	15,000,000
Idaho	7,000,000
Washington and Oregon	4,000,000
Arizona	500,000
New Mexico	250,000
Colorado and Wyoming	3,250,000
All other sources	1,000,000
	$67,000,000

"This is a decrease of $8,000,000 from the product of 1867, which showed a falling off of some $8,000,000 as compared with that of the year before. Montana, Idaho and Colorado, manifest a satisfactory improvement; but there is a decrease of $5,000,000 from California, and $6,000,000 from Nevada, the latter being due to the exhaustion of many of the Comstock ore bodies."

"It is an instructive fact that the greater product from deep mining is furnished by the same mines this year as last year and the year before, indicating that a more general adoption of systematic and economical methods would result in greater stability of production. The yield from placer mining must be exhibited to decrease, and its place must be supplied by the cement and quartz mines. The causes of the decrease in our production of bullion may be enumerated as follows:

"1. The exhaustion of many surface deposits.

"2. The reaction following upon a period of excited speculation and the collapse of numerous dishonest schemes.

"3. The increasing and novel difficulties attendant upon the management of deep mines and the reduction of refractory ores.

"4. The lack of communications, capital and knowledge, such as are required for the creation of enterprises based on the extraction and reduction of ores of low grade in large quantity—the only stable form of mining.

"5. The vexations and ruinous litigation which waits upon mining on the public dominion, and which is most troublesome and expensive where mining is, in other respects, most profitable—thus operating to destroy those enterprises which have overcome other difficulties."

"All these may be summed up in one sentence. Mining has been found in too many instances to be unprofitable; and the individuals who have lost money have retired from business. It certainly is not the duty of the government to give bounties to bolster up mining industry, if that industry is by the nature of the case an unprofitable one. Yet it cannot be denied that the decrease of the product of gold and silver in this country is a matter which particularly concerns the government at this time; and it may well be inquired, whether the causes of it are remediable. I believe that time will remove many of them, and that the action of government, based upon a just appreciation of its relations to the mining industry, will do away with the rest. Concerning the extent of our 'mineral resources,' the half has never been told; but those resources are but one factor, which must be joined with labor and intelligence to make the product wealth. When the industry of mining in these rich fields is based upon a foundation of universal law, and shaped by the hand of educated skill, we may expect it to become a stately and enduring edifice, not a mere tent pitched to-day and folded to-morrow. This industry has been the pioneer in our far-western territory. It has founded State, attracted population, enlarged the boundaries of civilization, and it has done this great work in a lawless and careless way, without much regard to the future. I believe that with the extension of the government surveys over the public domain, and the reduction of its vast area to order and law, the consolidation and definite adjustment of the mining interests will become imperatively necessary; and inasmuch as mining out runs all other activities in our new territories, and needs more than any other the aid of judicious legislation, I believe it should receive immediate attention."

We have quoted Mr. Raymond's reply to the Secretary of the Treasury thus extendedly, because his views are of such a practical character, and so worthy of the serious consideration of our people. We feel that our government, so liberal in its legislation in other matters—has not taken hold of this branch of our material wealth in a manner which the importance of the subject demands. We find that the most intelligent portion of our population does not comprehend the vast latent power—the power of gold and silver—which lies buried in the slopes of our great mountain chains of the west. The one individual fact that the Comstock Lode, of Nevada, has produced since its discovery in 1860, *one hundred millions of dollars*, should be sufficient to show that there is no single branch of industry in our land more worthy of thorough systematic, scientific development than that of mining. It is true that mining partakes of the lottery element to some extent, for one day the miner "strikes it rich" and the next day he may be in non-productive ground, but this is equally true of any business, however judiciously carried on. The curse of the west has been the formation of vast companies with bogus capital, and incompetent managers in charge of the mining operations. Companies made up of our best eastern capitalists have employed and continue to employ men as mining superintendents, who have not the first preliminary qualification which would fit them for their positions; these very business men who are so cautious in the employment of clerks or bookkeepers in their private business, exhibit the most remarkable lack of business ability in appointment of men to take charge of so important an undertaking as that of the development of a mine or the inauguration of metallurgical processes. We have known mining superintendents at the west who had never seen a mine until their arrival on the ground, and who did not know the difference between iron pyrites and native gold. Is it to be wondered at in view of these facts that mining operations—as a whole—have not been successful. At some future time we shall probably take occasion to discuss this subject of the employment of competent engineers in this branch of industry.

Part first of the report is devoted to observations on the present condition and prospects of the mining industry.

In his remarks on the New Almaden mines, Mr. R. says: "The quicksilver trade of the world is substantially an armed truce between Spain and California. The mine of Old Almaden, in Spain, supplies the market of London and a large part of Europe, and ships as far west as the city of Mexico. The New Almaden Co. got control of the Chinese market by underselling, and supplies of course the American demand, so that the world is about equally divided between these two companies. During the year 1868, the New Almaden produced 1,960,236 pounds quicksilver. Accounts of the principal mines on the great mother lode of California are given, together with the deep placers of Nevada county. A valuable chapter on the comparative merits of giant powder and common powder. The largest portion of the first part of the report is naturally devoted to Nevada, the mines of the Comstock being treated considerably in detail. The White Pine district and its wonderful deposits, comes in for a good share of attention. As an example we extract a portion of the account of the "Eberhardt" mine, its name having become almost synonymous with that of the cave entered by Aladdin." "At a depth of twenty or thirty feet from the surface drifts have been run in all directions *through solid masses of chlorides* or other ores of silver for twenty—fifty feet, and the end is not yet reached. Descending the shaft we found ourselves among men breaking down silver by the ton. The light of our candles disclosed great black sparkling masses of silver ore on every side. The walls were silver, the roof over our heads silver, the very dust which filled our lungs and covered our boots and clothing was a gray coating of fine silver. From a chimney in the Eberhardt ground $85,000 worth of silver was taken in a few days. One of the owners of the Eberhardt, but recently a poor man, values his interest at $1,000,000."

Since the above was written many other locations of equal value are claimed to have been made.

The notes on Montana, Arizona and other territories are not very extended, having been furnished to the commissioner by other parties; these territories will receive greater attention during the coming summer.

Part second, on the "Relations of Government to Mining," is a most important part of the report. The subject is discussed under the following heads:

Mining and Mining Law among the Ancient.

Mining Law in the middle Ages.

The Spanish Mining Law.

Modern German Codes. The Code of France. Mining Laws of England and Canada, and finally mining education, under which head accounts—with the course of instruction—are given of the Freeberg, Berlin, Clausthal and Paris Schools. In this second part information is given which cannot readily be obtained elsewhere. M.

CHEFS D'ŒUVRE OF THE INDUSTRIAL ARTS. (By PHILIPPE BURTY.) POTTERY AND PORCELAIN, GLASS, ENAMEL, METAL, GOLDSMITH'S WORK, JEWELRY AND TAPESTRY. Illustrated. Edited by W. CHAFFERS, F. S. A. London: Chapman & Hall, Piccadilly. 1869. Sold by Van Nostrand, N. Y.

Although this is not an engineering book, the subjects treated are of more than incidental importance to the engineer and the mechanician. There is much practical information concerning the processes and machinery of ornamental construction, but the charm of the book is thus expressed, at the close of a long review, in the "Builder":

To look carefully over this work brings an impression into the mind exactly like that which occupies it after a long day spent in the South Kensington Museum, or in the Louvre, or in the Vatican. And it also brings a desire to visit those courts and *salles* again, to see the lordly dishes and other triumphal specimens of the great ceramists, the clever, dainty, cunning enamels, the bronze and iron work of departed centuries, the sumptuous goldsmith's work and sparkling jewelry, with the new lights its perusal has conferred.

THE HISTORY AND PROGRESS OF THE ELECTRIC TELEGRAPH, WITH DESCRIPTIONS OF SOME OF THE APPARATUS. By ROBERT SABINE, C. E. Second edition, with additions. London: Virtue & Co. 1869. Sold by Van Nostrand, N. Y.

The following are the principal points in this work—early observations upon electrical phenomena, telegraphs by frictional and voltaic electricity, and by electro-magnetism and magneto-electricity. An excellent and most useful description is given of the various telegraphs now in use. Treating of construction, we find a large amount of information on overhead and submarine and underground lines; and the final chapter is given to atmospheric electricity. We feel sure that this edition, containing so much and such useful matter to the practical telegraphist, will be welcomed by all engaged in the profession as a most useful addition to their telegraphic library.—*Mechanics' Magazine.*

HANDBUCH FUR SPECIELLE EISENBAHN-TECHNIK, ETC VON E. HEUSINGER VON WALDEGG. Engleman, Leipzig, 1869. 8 vo., illustrated.

The first part of this work, which is promised to be completed in four parts, has appeared, and it is probable that it will prove the most complete and encyclopædic work upon every branch of railway construction and plant, bringing down the subject to the existing date, that has yet appeared. This first part commences with an able sketch (not everywhere absolutely free from slight errors) by Von Weber, Director of State Railways at Dresden, of the rise, progress, and history of railways. The remainder treats of the substructure of the way (without dealing with bridges, viaducts, etc.), of the table, ballasting, permanent way, fastenings, etc., of which copious details of all the many varieties on the German, American, and other lines are given; and with the manufacture, verification, choice, etc., etc., of rails, including the Bessemer manufacture of steel rails. There is a chapter of some interest upon the theoretic principles of the resistance of rails laid into way. One excellent feature of this really fine work, which is well illustrated both with engraved plates and by woodcuts in the text, is a very complete bibliography and reference, at the end of each chapter, to all published papers upon its particular subject. These lists are chiefly of German works, but also contain those in most of the other European languages. The book is wonderfully cheap, considering its illustrations. We cannot say we have met with anything perfectly new to us in this first part.—*Practical Mechanic's Journal.*

APPLEBY'S ILLUSTRATED HANDBOOK OF MACHINERY AND IRON-WORK. By APPLEBY BROTHERS. E. and F. N. Spon, 48, Charing-cross.

We have here a handsomely published volume of some 450 pages, which endeavors to appear as little like a catalogue as possible, but with very indifferent success. As a general catalogue it is admirable, containing, as it does, between three and four hundred wood engravings, and the prices of at least two thousand machines and miscellaneous articles. The first section is devoted to drawings and prices of steam cranes, travelers, winches, and steam-hoisting machinery; the second to engines, boilers, turbines, and dredgers; the third to steam and hand pumps, hydraulic machinery, motors, and fittings; the fourth to contractors' plant, the fifth to machine tools, and the sixth principally to agricultural implements. Added is a small collection of tables, memoranda, and information for engineers, possessing no great merit, and open to considerable improvement. But, as a price-book of general machinery, Appleby's handbook is more complete than any which has yet been brought under our notice.—*Engineering.*

THE ELASTICITY, EXTENSIBILITY, AND TENSILE STRENGTH OF IRON AND STEEL. By KNUT STYFFE, Director of the Royal Technological Institute at Stockholm. Translated from the Swedish. With an Original Appendix by CHRISTER P. SANDBERG, Assoc. I. C. E. With a Preface by JOHN PERCY, M. D., F. R. S. John Murray: London. 1869. For sale by D. Van Nostrand, 23 Murray street, New York.

This work is attracting great attention among iron and steel makers and constructors. It is reviewed and quoted at great length by "Engineering," "The Engineer," and other authorities. It contains the result of a series of experiments conducted by a committee appointed by the King of Sweden, with the view of examining railway plant of home manufacture, and of determining the fitness of Swedish iron for such materials. The experiments were spread over several years, and had reference to the elasticity, "extensibility," and absolute strength of different varieties of iron and steel. The tests were carried out under the direction of Professor Knut Styffe, director of the Royal Technological Institute at Stockholm, a gentleman whose lifelong training in experimental science eminently qualifies him for the task he has undertaken. It is no small recommendation of the author which Dr. Percy gives in his preface to the work: "From the high position which I know he occupies in the estimation of scientific men in Sweden, perfect confidence may be placed in the accuracy of his results, though his conclusions may not in every case be accepted." The volume contains a large amount of information, carefully collected from trustworthy experiments; it is illustrated with numerous, although not very artistic, working drawings. An eminent authority on such matters—viz., Mr. Fairbairn, writes: "I have great pleasure in bearing my testimony to the scientific and practical value of your translation of this important work, and, looking to the innumerable uses to which this material is applied, I have no hesitation in recommending it to the perusal of the architectural and engineering public." The author divides his book into four chapters, the first treating of experiments on tension at ordinary temperatures; the second, of the application of the results of these investigations to the determination of the relative values of steel and iron, and of the different varieties of these materials, for different purposes; the third, of experiments on tension at high and low temperatures; and the fourth, of experiments on flexion at different degrees of temperature. To these chapters are added various tables and plates, and also a valuable appendix by Mr. Sandberg.

The work, however, useful as it is in many particulars, is severely criticized. "The Engineer" pronounces it impractical and obscure, although painfully precise. Many of the considerations are quite new to iron workers in this country, at least, and will be farther referred to.

DISINFECTANTS AND DISINFECTION. By ROBERT ANGUS SMITH, Ph. D., F. R. S., F. C. S. Edinburgh: Edmonston and Douglas, 1869. For sale by Van Nostrand, New York.

By common consent, Dr. Angus Smith has become the first authority in Europe on the subject of disinfectants. To this subject he has devoted a large portion of his scientific life; and now, in a compact volume of only 138 pages, he has condensed the result of twenty years of patient study. We cannot too much commend the plan and execution of this inquiry. Almost every page contains evidence of exhaustive, laborious research, guided in its course by the clearest judgment. We seek in vain for some weak point to give us occasion to air our critical acumen. Our duty, therefore, must be confined mainly to giving extracts—criticism being out of the question—for no man living is competent to criticise Dr. Angus Smith on disinfection but Dr. Angus Smith himself—*Chemical News.*

THE MILLING JOURNAL AND CORN EXCHANGE REVIEW. New York: J. D. Nolan & Co. Publishers, 95 Liberty.

The number of American journals devoted to special subjects is receiving constant additions. We have just received a copy of a new monthly journal devoted to the subject which its title, given above, indicates. The milling businees is one of vast magnitude in this country; and we should think there is a fine opening for a paper treating of it. The copy before us gives fair promise of success.

The above notice is from the "American Artizan;" we can fully indorse it, and we may add that the new journal has more practical information than most of the journals among us, that treat of special features of science and mechanics. Milling is a subject of sufficient scope and importance to require quite as good a special organ as for instance telegraphy and gas lighting, and this demand is likely to be supplied, if the mill managers and mechanicians especially interested do their part. They will be the losers if such a journal is not properly encouraged.

THE AMERICAN MILLER AND MILLWRIGHT'S ASSISTANT. By W. C. HUGHES. Price $1.50 post paid. Same publisher.

This is another extremely useful work on milling, and will be found a most acceptable compendium for references. It embodies the best information derived from the author's personal knowledge and practical experience. Few intelligent millers, we are persuaded, will long remain without it. It is a plain, practical treatise, written in a style which will be easily understood, and cannot fail to be of incalculable value to apprentices, and others, who have a desire to perfect themselves in every branch of milling.—*Milling Journal.*

THE AMERICAN YEAR BOOK AND NATIONAL REGISTER FOR 1869. Edited by DAVID N. CAMP. Hartford: Published by O. D. Case & Co.

This work is the initial volume of a proposed annual publication, respecting the affairs of the General and State Government, public institutions, finances, resources and trade of this country; the political, financial and social conditions of other countries; and various other subjects relating to social and political economy. The work is a thick 8vo., printed and bound in excellent style; and seems a valuable work of reference.

THE PHENOMENA AND LAWS OF HEAT. By ACHILLE CAZIN. Translated and Edited by ELIHU RICH. pp. x., 265. New York: Charles Scribner & Co.

We have here an additional volume in the series of popular works on the wonders of science, which Scribner & Co. have recently introduced into this country. It is written in a style entirely intelligible, even to persons without scientific training, and the numerous illustrations add greatly to the interest of the text.

Law of Patents for Inventions; with Explanatory Notes on the Law as to the Protection of Designs and Trade-Marks. By F. W. Campin. London: Virtue & Co. 1869.

This book is highly recommended, and reviewed at length in "Engineering," which authority says: "Mr. Campin's book throws a clear light upon the subjects of patents and patent law in all its stages, and is illustrated by a host of the most pertinent cases."

Although the details of proceedings in the British Patent-Office are of limited importance to others than professional solicitors of patents in this country, the elucidation of British patent law is valuable to all men, here as well as in England, whose claims are or are likely to be involved. British precedents are as much relied on in our courts as at home.

MISCELLANEOUS.

ENGLISH AND FRENCH MEASURES.

From "The Engineer."

Lengths—Longueurs.

1 inch = 0.0254 mètres
1 foot = 0.3048 mètres
1 yard = 0.9144 mètres
1 chain = 20.1160 mètres
1 mile = 1609.315 mètres
1 millimètre = 0.394 in.
1 centimètre = 0.3937 in.
1 mètre = 3.281 ft. = 3 ft. $3\frac{3}{8}$ in.
10 mètres = 32.809 ft. = 10.936 yds.
1 hectomètre = 100 metres = 328.090 ft. = 109.363 yds. = 4.971 chains
1 kilomètre = 3280.90 ft. = 1093.63 yds. = 49.71 chains = 0.621 miles
1 knot = 6082.66 ft. = 1.152 miles = 1853.931 mètres
£1 per mile = 15.525f. per kilomètre
100f. per kilomètre = £6.437 per mile.
1f. per mètre = 8.778d. per yd. = 2.926d. per ft.
1s. per yard = 1.367f. per mètre
1s. per foot = 4.101f. per mètre
1 kilomètre = 0.539 knots

Areas—Superficies.

1 square inch = 6.4513 c|m^2
1 square foot = 0.0929 m|^2
1 square yard = 0.8361 m|^2
1 rod = 25.2919 m|^2
1 acre = 0.4047 hectare
1 mm|^2 = 0.00155 square inches
1 c|m^2 = 0.1550 square inches
1 m|^2 = 1.1960 sq. yds. = 10,7643 sq. ft.
1 are = 100 m|^2 = 0.0247 acres
1 hectare = 10,000 m|^2 = 2.4711 acres
1s. per square foot = 13.455f. per m|^2
1s. per square yard = 1.495f. per m|^2
1f. per m|^3 = 8.0266d. per square yard
£1 per acre = 61.778f. per hectare
100f. per hectare = £1.6188 per acre
100f. per are = £0.0162 per acre

Measures of Capacity, Dry and Liquid—Mesures de Capacité pour les Liquides et les Grains.

1 pint = 0.5679 litres
1 quart = 1.1359 litres
1 gallon = 4.5435 litres
1 peck = 9.0869 litres
1 bushel = 36.3477 litres
1 sack = 1.0904 hectolitre = 109.0430 litres.
1 quarter = 2.9078 hectolitres
1 chaldrou = 13.0852 hectolitres
1 litre = 1.7608 pint
1 decalitre = 2.201 gallons
1 hectolitre = 22.010 gallons
1s. per gallon = 0.2751f. per litre
1f. per litre = 43.618d. per gallon

Volumes.

1 cubic inch = 16.3870 c m^3
1 cubic foot = 0.0283 m|^3 = 28 litres
1 cubic yard = 0.7645 m|^3 = 765 litres nearly
1 c|m^3 = 0.061 cubic inches
1 d|m^3 = 1 litre = 0.0353 = 61.028 cub. in.
1 m|^3 = 1.3079 cubic yds. = 35.322 cub. ft.
1 m|^3 of distilled water (*eau distillée*) = 1 *tonneau de mer*, weighing 1000 kilogrammes
1s. per cubic foot = 44.150f. per m|^3
1s. per cubic yard = 1.6349f. per m|^3
1f. per m|^3 = 7.339d. per cubic yard = 0.272d. per cubic foot

Power—Force.

(Horse-Power, H. P.—Force en Chevaux.)

1 H. P. is the force that will raise 33,000 lb. to a height of 1 foot in 1 minute.

1 *cheval-vapeur élève* 33,000 *lb. à* 1 *pied de hauteur en* 1 *minute; ou* 75 *kilogrammes à* 1 *mètre en* 1 *seconde.*

1 kilogrammètre is the force that will raise 1 kilogramme to a height of 1 mètre
1 H. P. = 75 kilogrammètres per seconde
1 Dynamie = 1000 kilogrammètres

Pressures—Pressions.

1 lb. per square inch = 0.0703 kilos per c|m^2
1 kilo per centimètre = 14.229 lb. per sq. inch.
1.033 kilo per centimètre = 14.73 lb. per sq. inch = 1 atmosphere

Railway Earthworks—Terrassements.

1000 cubic yards per mile = 474.755 m|^3 per kilomètre
1000 m|^3 per kilomètre = 2104.823 cubic yards per mile

Rails.

1 lb. per yard run = 0.4958 kilos per mètre
1 kilogramme per mètre = 2.0168 lb. per yard = 0.6723 lb. per foot

A Model Establishment.—It is a remarkable fact that Mr. Krupp—in business for forty years, and with not less than 10,000 men for some years in his employment—has never had a dispute with a workman; a fact, doubtless, ascribable in a great measure to the admirable institutions and regulations for the benefit of the workmen. By one of the provisions of the establishment, every workman becomes entitled, after twenty years' work, to a retiring annual pension of half his last year's salary, and after thirty-five years he may retire on full pay. Such regulations, however effective they may be, do not appear to explain the extraordinary concord and order perpetually maintained in this enormous establishment. From 1,000 to 1,400 men are frequently engaged at one operation, such as casting an ingot. They work as one man, and the same harmony and regimental order prevails throughout. It is, doubtless, traceable, in part, to the military training which every Prussian receives. —*Fortnightly Review.*

A New Movement.—*Apropos* of the article on another page, relative to the perfecting of existing American Scientific Schools, we are happy to learn that the alumni of the Rensselaer Polytechnic Institute, at Troy, propose to assemble at that place on the 22d and 23d of June next, for the purpose of forming themselves into a permanent association; partly, no doubt, for the purpose of inquiring into, and intelligently representing throughout the land, the interests of that Institution, which, in certain respects, have long been strangely and lamentably neglected. We hail this movement with great pleasure from every point of view. It is, we believe, the first one of its kind in the country; that is, the first made by the graduates of any of our Technical Schools. It will rally to the support of an old and honored institution the affections and counsels of an able body of graduates, and will naturally stimulate effectual inquiry into its wants, and the reasons why they have been so loug unsupplied, and the best means of meeting them. It will naturally still further attract the friendly attention of the whole engineering profession throughout the land to au Institution which, amid many discouragements, has striven indefatigably to honor that profession by raising the standard of entrance upon it. It will thence properly cause the Institute to be more widely known and appreciated by the general public. We have seen the circular, calling the meeting, which is sent to every accessible graduate, and take pleasure in here giving publicity to the proposed movement, in order that all concerned may be the more sure to be advised of it, and may be the more certain to attend.

The Dust of Cities and the Health of Men.—A microscopist (Mr. Dancer, F. R. A. S.) has, says the "Daily News," been examining the dust of our cities. The results are not pleasing. In every specimen examined by Mr. Dancer, animal life was abundant. But the amount of "molecular activity" is variable according to the height at which the dust is collected. And of all heights which these molecular wretches could select for the display of their activity, the height of five feet has been found to be the favorite. Just at the average height of the foot-passenger's mouth these moving organisms are always waiting to be devoured and to make make us ill.. A large proportion of vegetable matter also disports itself in the light dust of our streets. Mr. Dancer's observations show that in thoroughfares where there is much traffic a large proportion of this vegetable matter thus floating about consists of what has passed through the stomachs of animals, or has suffered decomposition in some way or other. This unpleasing matter, like the "molecular activity," floats at a height of five feet, or thereabouts. These observations tend to a recognition of the manner in which some diseases propagate themselves, and the lesson to be deduced is that the watering cart should be regarded as one of the most important of our hygienic institutions. Supplemented by careful scavengering it might be effective in dispossessing many a terrible malady which now holds sway from time to time over our towns.

Screw vs. Paddle.—The splendid Cunard paddle steamer Persia has been sold for £15,000. Meanwhile no paddle steamers are building for the Atlantic lines. The Pacific Mail still sticks to paddles.

The Channel Bridge.—It appears from the French papers that a proposal has been made to M. Boutet, the projector of this enterprise, to undertake the connection of the town of St. Malo with the French coast by a causeway or viaduct, constructed on his system, and that the Anglo-French Channel Bridge Company are about to undertake this work. The town of St. Malo stands upon an island, distant from the mainland, with which, however, it is in some measure connected by a causeway, usually covered by the sea. A road raised upon a bridge such as M. Boutet has proposed for crossing the Channel, would, therefore, be a great advantage to such a locality, and it would afford the company an excellent oppoitunity of demonstrating the feasibility of M. Boutet's mode of construction, which, indeed, seems to be pretty well acknowledged in Paris. The proposition forms the subject of a very elaborate criticism in the February number of "Le Genie Industriel," a valuable and influential French work, which has been long devoted to the examination of leading scientific works. The writer of the article in question, M. Fieort, demonstrates the theoretic soundness of the principles on which M. Boutet relies.—*Mining Journal.*

The new P. & O. Steamship "Deccan."—This vessel is the latest addition to the Peninsular and Oriental Company's fleet. Her dimensions are as follows: Length betwcen perpendiculars 345 feet; breadth of beam 42 feet; depth of hold 30½ feet; builder's measurement 3,001 tons; gross tonnage, 3,128. Her engines are of 600 nomiual horse-power (indicating 2,730 during her trial); diameter of cylinders 76 inches, and length of stroke 4 feet; and has a four-bladed propeller 18 feet 10 inches in diameter, with a pitch of 27½ to 30½ feet, aud weighing 12¾ tons. Two runs at the measured mile showed the following results:—Steam, 25 pounds; vacuum, 28 inches; revolutions, 52; the true mean speed being 13.733 knots per hour, with a mean draught of 18 feet 8¼ inches. The heating surface of the boilers is 12,504 square feet, fire-grate surface 420 square feet, and condensing surface 5,864 square feet.

Drying Green Wood..—A new method for drying green wood in a very short time, says the "Builder," consists in boiling it for some hours in water and leaving it then to eool, by which the soluble substances are removed. It is then boiled in an aqueous solution of borax, by which the insoluble albumen of the wood is rendered soluble, and escapes from the pores. The wood is then placed in drying-chambers, heated by steam, and allowed to remain three days.

American Institute.—The vacancy in the Faculty of the American Institute, caused some three years since by the death of Prof. James J. Mapes, has been filled by the appointment of James A. Whitney, associate editor of the "American Artisan," as Professor of Agricultural Chemistry.

Technical Education.—The English Government have decided not to establish schools of technical education throughout the country, as the expense would be enormous. They have resolved, however, to give liberal support to local efforts made for this purpose.

The French Atlantic Cable will be laid in June. Its length will be 3,564 nautical miles, from Cape Ushant, a few miles from Brest, via the French Island of St. Pierre (near Placentia Bay, Newfoundland), to Cape Cod, landing at Plymouth, Massachusetts. The cable will be an improvement in every respect, upon that of 1865-6. It will weigh 400 instead of 300 pounds to the mile. The London Times says: "the standard of the manufactured value of a cable is judged by what are called its units of resistance to the passage of the electric current through the conductor, and the more perfect the insulation the greater that resistance will be. This resistance, measured by the galvanometer, is counted by millions of units. The Indian Government insisted on the Persian Gulf cable having a resistance of 50,000,000 of units. The standard of the Atlantic cable of 1865 was raised to 100,000 units. In the cable of 1866 the standard was raised to 150,000,000 units, and in this French cable the contract standard is 250,000,000 units of resistance and no less; and in this high electrical condition it will be laid. After it is laid every day will improve its insulation. Thus the two Atlantic cables have gained so much in insulation since they left the factory that often during last year, it is said, they gave a resistance as high as 4,000,000 units."

Granite Paving v. Macadam.—The question of the relative durability and safety of these two methods of covering metropolitan streets and roads has undergone much discussion lately by the various vestries, and as it is beginning to be discovered that paving is cheaper in the long run, it is likely that a great deal of paviors' work will be done in the metropolis within the next two years. The advocates of granite cubing seem to be in a majority everywhere, and financial difficulties only stop the way in most cases. The employers of horse power throughout the metropolis prefer paved roads, and no wonder when in the course of the year so much rough unconsolidated broken granite has to be traversed by them, to the injury of the animals, and to the detriment of springs and wheels. Those who object to paved streets on account of the increased noise of the traffic have, to a great extent, to thank the barbarity of modern road making for the development of the present movement in favor of paved roads. The adoption of the steam road roller would not only have been an act of humanity towards our horses, but it would have enabled macadamised roads to be kept in constant repair at a far less cost than by the present slovenly method. —*Building News.*

Steam-Engines and Machinery.—The returns as to the exports of machinery and steam-engines from the United Kingdom for the first 11 months of last year are sufficient to enable us to form a pretty good estimate as to the year's business. We sent last year fewer steam-engines to France, Egypt, British India, and Australia. Russia, however, came to the rescue, and took our steam-engines to the value of £260,537 in the 11 months ending Nov. 30 last year, as compared with £66,522 in the corresponding 11 months of 1867. The falling off in the demand for railway engines in British India rather seriously prejudiced the general result of last year's operations; to Nov. 30 however, we sent abroad steam-engines to the value of £1,598,-795, as compared £1,829,578 in the corresponding eleven months of 1867, and £1,611,442 in the corresponding 11 months of 1866. In the year 1858 we only exported steam-engines to the value of £1,097,278, so that the general course of this branch of our exports is onwards. The exports of general machinery showed very little variation, upon the whole, last year, but the case would have been otherwise but for the augmented demand from Russia.

Enameling of Iron Vessels.—The enameling of saucepans and other articles in wrought or cast iron has long been practiced, a very fusible enamel reduced to powder being sprinkled ovey the surface of the iron when heated to redness; but as the mixtures employed consist of highly alkaline silicates, the enamel is not very durable, and will not withstand acids or even salt liquids. An improved process has been introduced in France. The metallic surface is brought in contact with the ingredients of ordinary white glass, and heated to vitrification; the iron is said to to oxidize by combination with silicic acid, and the glass thus forms one compact body with the metal. The coating of enamel may be laid on as thinly or as thickly as desired, but a thin coating is better as regards the effect of expansion or dilatation. Experiments are being made in coating the armor plates for ships in the manner above indicated.—*Scientific American.*

Architectural Library.—The New York chapter of the American Institute of Architects propose to establish in New York a library of works on architecture and the cognate arts for the benefit of students, not of architecture only, but of those branches known as industrial designing. The excellent tendency of such an enterprise is obvious. The more our architects know, the better and more economical will our buildings be. The members of the Chapter have already begun a subscription, and those who are interested should apply to Alfred J. Bloor, Secretary, 42 East Fourteenth Street, New York.—*Harper's Magazine.*

Education.—A Convention of American Philologists will meet at Poughkeepsie on the 27th of next July, to consider some very practical questions, as, How much time in college should be given to the study of language? How much to modern languages? What is the best method of instruction in the classical language? What position should be given to the study of the English language in colleges and high-schools? The call is signed by many of the most noted instructors and scholars in the country, and the meeting will undoubtedly be both interesting and serviceable.—*Harper's Magazine.*

Great Art Prize in France.—In the month of August is to take place the first award of the great prize of 100,000f. instituted by the Emperor Napoleon III. to be voted by the Academy of the Beaux Arts and the Institute of France to the French artist, painter, sculptor, or architect who shall have produced, and entirely completed within the five years preceding the time of the award, a work of great excellence. The jury is to consist of thirty members—ten sculptors, ten painters, and ten architects. In case any of the members of this jury should become candidates for the prize, they will retire from it, and their places will be filled up by the Academy.—*Building News.*

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PAPERS ON CONSTRUCTION.

No. III.

RELATIONS OF SAFE LOADS TO ULTIMATE STRENGTH.

By Lieut. C. E. Dutton.

(Continued from page 501.)

A comprehensive series of experiments, united with exhaustive theoretical investigation into the relation of safe loads to ultimate strength is greatly needed. Not merely are there wide differences in the practice of the most accomplished engineers in this respect, but even the fundamental principles upon which the various practices are founded seem to be arbitrary rather than rational. In England, where experiences have been wider, and where the economical aspects, certainly, of engineering have been more assiduously cultivated, the arbitrary character of practice is a marked feature. Thus, the Board of Trade regulations prescribe that the working load shall never subject any part of an iron structure to more than five tons of tensile strain per sq. inch. It is obvious that the nearness of this standard to the highest economy will depend, in a great measure, upon several considerations, either one of which may modify extensively its value. First, the resistance of wrought iron to crushing is less than to extension, whether we take its ultimate resistance or its moduli of elasticity. The ratio of these two resistances may be stated at $\frac{4}{5}$, so that if five tons per square inch are just a safe load for tensile strains, they are unsafe for compressive strains; and since, in girders of a symmetrical cross section, these two strains are equal, the fallacy of such a standard becomes apparent. Secondly, the qualities of different grades of iron differ widely both in respect of tensile strength and homogeneity; and, it may be added, in the ratio of tensile to compressive resistance—circumstances whose modifying effect is too plain to need comment. Thirdly, the details and kind of structure may be such that vital parts may be exposed to strains more complicated than simple tensile or compressive stress, the exact nature of which may not be fully ascertained nor contemplated in such an estimate of strength.

Other considerations may also be suggested, which show, in the aggregate, that no such arbitrary standard can insure the highest economy of strength consistent with perfect safety. The wide differences of opinion on this subject may be illustrated by stating that when, a few years ago, it was made a subject of special inquiry by Parliament, Mr. Glynn, in his evidence, recommended that a cast iron bridge should never be loaded beyond one-tenth of its ultimate strength. Mr. Stephenson and other accomplished builders recommended one-sixth, and Mr. Brunel thought one-third, or even two-fifths, a safe margin. Perhaps there is less, much less, difference in the practice of to-day than in that of twenty years ago; the various factors of safety ranging, generally, between one-fourth and one-sixth. But even here it may be fairly asked, how much of this approach to uniformity is merely arbitrary, and how much is founded upon sound theory and carefully considered practical and experimental results. Probably a great deal of the former, and very little of the latter.

With the increased knowledge now possessed of the nature and properties of iron, and its behavior under loads, it would seem that a series of experiments might be instituted with a fair prospect of most valuable results. In the smaller structures, which are thrown up daily in our cities and over streams, the matter may not possess such vital importance, though even here the frequent failures recorded call loudly for reform.

But the tendency of to-day is towards structures which, a few years ago, would have been thought as romantic as air castles, and in these economy possesses a vital importance; indeed, may frequently constitute just the difference between the practicable and the impracticable. With every increase of size the weight of a structure bears a larger ratio to its strength, so that, with given proportions of members, it is easy to calculate the limit at which the whole available strength of it is employed in sustaining its own weight. It is clear, then, that every new acquisition of knowledge which will enable us to determine, with tolerable certainty, the smallest margin of safety, amounts to an extension of the limits of practicability, and to a decided facility in constructions within those limits. We hope to indicate the directions in which theoretical and experimental research may become useful, and the facts which may be made the basis of investigation.

1. The behavior of materials, particularly of iron and steel, under those strains which can be produced experimentally, should be especially and primarily noticed. It seems to us that the use of the ultimate strength of iron, as a standard of reference in determining its available strength, is bad in principle. Ultimate strength, in its general acceptation, means the resistance of a standard bar or rod of the material to rupture by forces applied to it *when new*, and applied, too, during a very brief portion of time, possibly only once. The testing machines usually employed exert their power upon bars of metal fresh from the forge, and rend them by a single effort in a few seconds or minutes. There is, in all this, nothing analogous to rupture produced by protracted wear and tear. We must consider, not merely the well known fact that materials change their molecular structure by time, and the long continued and repeated applications of forces, but that the amount and kind of change so effected, and the exact results upon its strength are quite unknown.

2. Still more pertinent to the case is the fact that the ultimate strength is of little consequence, because no structure must be subject to strains beyond the limits of elasticity. The force under which marked and permanent changes take place in the forms or dimensions of the materials used is necessarily without the limit of safety, for our knowledge of materials assures us that in such a case rupture is merely a matter of time. This lower limit, then, is the only one which practically bears upon the case, and its relation to the higher one of ultimate strength is by no means understood. It is even doubtful whether any definite relation exists at all.

Experiments upon the ultimate tensile strength of materials have been numerous and almost exhaustive. Nearly every book treating of materials contains tolerably complete tables, both of tensile, compressive and transverse strength, determined experimentally. What is far more essential is a reliable table of strains at which these same materials begin to elongate, or collapse into permanent set. To deduce these strains from the ultimate strength is impossible, as the following examples, found in Barlow, will show. The experiments were made by Mr. Brunel.

No.	Began to stretch. Tons per sq. in.	Breaking weight. Tons per sq. in.	No.	Began to stretch. Tons per sq. in.	Breaking weight. Tons per sq. in.
1	21.	29.8	1	28.12	36.12
2	24.	32.	2	27.4	36.4
3	defective	......	3	24.16	32.16
4	22.	34.19	4	27.16	33.10
5	20.	34.6	5	22.15	31.14
6	20.	28.2	6	25.18	31.15
7	23.2	28.2	7	22.3	31.9
8	24.	31.6	8	21.9	29.6
9	26.9	32.11	9	23.9	31.7
10	23.1	28.12	10	21.9	30.7
Mean,	22.2	30.4	....	24.44	32.3

The iron used was the best Yorkshire, hammered in rods $\frac{3}{8}''$ and $\frac{1}{2}''$ square.

We must here lay down, as well as we are able, what we understand by the limit of elasticity in any particular case. In the preceding table the specimens ostensibly begin to change their forms and dimensions under a stress somewhere near three-fourths the breaking stress. But it is well known that both wrought and cast iron take permanent set at far lower stresses. Indeed, it is asserted by some eminent authorities that any application of force, however slight, will produce permanent change in iron, though the change may be so small as to escape detection by the most delicate measurements. Allowing this to be true (for there is no intrinsic improbability in it, although it has no practical importance) is there any essential difference between the set produced by the application of twenty tons per inch, and that by the application of one ton, excepting the difference in degree; in other words, is there any essential difference in the nature of the changes produced by the two cases in the molecular arrangement of the material? We venture to suggest that there is an essential difference. It is well established, by many experiments, that iron stretched by weights not exceeding, say, one-third the ultimate strength, resumes *nearly* its original dimensions; but not exactly. The difference is called the set. We are left to infer that this difference is the result of certain molecular changes, but can only surmise their character. Some light may be thrown upon the subject by connecting together the following facts. All varieties of iron consist of agglomeration of minute crystals, octahedral in their fundamental forms, but in most cases also fibrous or minutely acicular, both in cast or wrought iron. The major axes of these crystals have a tendency towards parallelism; *i. e.*, the axes of a considerable portion of the crystals are parallel, or approximately so. In wrought iron this tendency towards, or actual, parallelism is produced by the ductile action of rolling or hammering, compelling the molecules to slide over each other in one direction, during which process they most readily assume the acicular or fibrous structure. In cast iron, also, a definite arrangement takes place in parallel facets, by reason of the escape of heat in particular directions (*i. e.*, in lines normal to the nearest surface of the mass) in passing from the fluid to the solid state. It is not essential to the fibrous condition that all, or nearly all, the crystals should be parallel, but that a considerable portion of them should be so, sufficiently to indicate a tendency to parallelism in a particular direction in preference to any other.

In the case of wrought iron, when the peculiar action of rolling and hammering is considered, it is more than probable that some of the fibers are left in a state of initial tension, and others in a state of initial compression. Under such conditions the application of even a slight degree of force may be sufficient to produce molecular change at points where such tensions exist. In the case of tensile stress, the limit of cohesion between two contiguous atoms may thus be exceeded, and a redistribution of atoms will be most likely to take place by the sliding of other atoms into the interval produced, so that when the stress is removed the tendency to a perfect restoration is resisted at this particular point. In the case of compressive stress, the atoms at points of initial compression may be thrust out of their original situations, and contact effected between atoms which were before separate. and the tendency to restoration after the removal of the stress no longer exists at these points. If we suppose, as is most natural, that these initial forces are of all degrees of intensity between zero and the limit of elasticity, we have here the explanation of the phenomena of permanent set. The effects just described will be approximately proportional to the forces applied. And so we find it very nearly in practice. There are, it is true, departures from the ratio, but not greater than might be expected from the imperfect homogeneity of the metal.

A single application of stress producing a perceptible set, and, according to the views just expressed, occasioning a molecular change in the metal, need not sensibly impair the strength of the iron, for the rearrangement of the atoms may be, and in most instances probably is, as favorable for further resistance as the original one, if not more so. Many repetitions of the stress, however, or the constant action of vibrations during a continuous stress, may produce arrangements less favorable. The tendency to assume the form of large specular crystals seems to be very decided under such conditions, at least, if the strain be tensile. The whole mass being elongated, and the intermolecular spaces being increased, there is afforded, as it were, a sort of facility to the atoms to obey those laws of crystallization inherent in the constitution of all solid matter. Observation and experiment confirm this view.

If there is any measure of truth in the foregoing speculations, it follows that there is a limit of stress at which the cohesive power of every portion will be exceeded, and a general change in the structure of the mass will supervene. If the constitution of the material is such that the atoms can rearrange themselves readily, the material will behave like a tough, pasty mass, elongating considerably, diminishing in size laterally. If it is strongly crystalline, and the atoms refuse to rearrange themselves, rupture is immediate. The former is the case with good wrought iron, and the latter with cast iron.

In a similar connection Mr. Zerah Colburn remarks, "It would be interesting to know the successive positions of the atoms during the application of the strain. We are, however, without any positive knowledge of the positions which the atoms assume in solidification, and under subsequent forging; but the multifarious forms in which all atoms visibly crystallize serve to show us that they cannot all be at equal distances from each other throughout the whole body. If they were, the arrangement would be that of cannon balls in a triangular pyramidal (or prismatic) pile. Could we visibly represent the atoms as occupying the angles of an infinite number of equilateral triangles we should understand that a linear strain, acting to separate any two of the atoms, would, at the same time, draw a third atom, if not a number of atoms, partly between them. And when, from this intrusion, the repulsive force, always enveloping the intruding atom, had once overpowered the attractive or cohesive force existing between the two atoms thus strained apart, these would, in turn, cohere anew to the atom which had been drawn in between them, and thus we should have a permanent rearrangement of the atoms, or, in other words, a permanent set with permanent elongation in one direction, and permanent contraction in a plane at right angles thereto. That the atoms are thus drawn into parallel rows in many kinds of iron, at least, seems evident from the appearance of fracture, which presents stringy collections of particles, forming what is commonly called fibre, although there is great reason for doubting that anything like fibre existed in the iron before it was broken. Mr. Kirkaldy's recent experiments appear to show, as many others have shown, that iron may be made to break short, or to break with an appearance of fibre, just according as it is broken with a sudden blow or gradual pull."

We attach slight importance to the conclusions from Mr. Kirkaldy's experiments, since they furnish only negative evidence, against which may be cited positive evidence of the strongest kind. They merely show that the fibre is not apparent when iron is suddenly broken. On the other hand, it is not only distinctly apparent when it is broken gradually in the direction of its length, but when pieces cut from a bar transversely are pulled asunder the surfaces of rupture give unmistakable indications that we are obtaining a side view of the fibre. Finally, the strength of wrought iron is from two to four times greater in the direction of the assumed fibre than in a direction perpendicular to it, showing that the arrangement of the constituent particles differs widely in the two directions.

We think some confirmation of the views we have set forth will be found in the fact, that rods of wrought iron, subjected to gradual pulls beyond the limits of elasticity, have their strength not only unimpaired, but actually increased by the strain. If the two fragments of a broken rod be submitted again to rupture, the forces required to effect it in each fragment are almost always decidedly greater than that accomplishing the first rupture. This increase of strength will be found to be more decided in proportion to the softness, or ductility of the iron used. Doubtless the same causes which produce this effect produce also the great increase of strength imparted to iron and steel when drawn into wire. Mr. Barlow gives the results of experiments made at the Woolwich dockyard with reference to this phenomenon, which show an increase amounting, in some cases, to 18 per cent. Mr. Colburn mentions the experiments of Mr. Thomas Lloyd, engineer to the Admiralty, on ten bars of Crown S. C. iron, $1\frac{3}{8}$ inches in diameter and $4\frac{1}{2}$ feet long. The mean breaking weight at the first breakage was 23.94 tons per square inch. At the second breakage the mean strength was 25.86 tons per square inch. At the third breakage it was 27.06 tons per square inch. At the fourth breakage it was 29.2 tons per square inch. The mean strength at the last breakage was about 22 per cent greater than at the first. Mr. Colburn suggests, as an obvious explanation, that the bars first broke at the weakest point, then again at the next weakest, and so on. But this seems to disregard the fact that these bars elongated several inches before breaking, which must necessarily involve a complete rearrangement of its constituent atoms throughout its mass, so that the section of minimum strength was constantly altering, if not its position, certainly its ultimate structure. The process, on the contrary, seems to us quite analogous to wire-drawing, the atoms arranging themselves more and more thoroughly in the form of parallel fibres, which is the position most favorable for tensile resistance, until a maximum of parallelism is reached, and therefore a maximum strength.

Taking into consideration the nature and structure of cast iron, it can hardly be expected that it can be as strong after the application of severe strains as before. Rupture must always ensue whenever the elastic limit is exceeded. A continued repetition of strains ought, upon the foregoing principles, to deteriorate the strength by the successive rupture of the cohesion of detached points. Experience in cast iron guns leads to this conclusion, but exhaustive experiments upon various forms, with stresses variously applied, are much needed.

The following valuable considerations by Mr. Colburn are added: "In a paper of great value, read nearly seven years ago before the Royal Irish Academy, and afterwards published in a quarto volume entitled, 'On the physical conditions involved in the construction of artillery,' Mr. Robert Mallet has laid down a useful measure of the working and ultimate strength of iron. Poncelet had already employed co-efficients, which indirectly expressed, not merely the elastic limit and breaking strength of iron, but the range also, through which the force acted in each case, in reaching these limits. Mr. Mallet has adapted these co-efficients to the English standard of mechanical work, viz, 'foot pounds;' and he represents the structural value of different materials, or of different qualities of the same material, in one case, by the product of the elastic load in pounds into half the range in feet, or parts of a foot, through which it acts, and in the other case by the breaking weight in pounds multiplied also by half the range in feet, or parts of a foot, through which it acts. Mr. Mallet employs Poncelet's co-efficients as follows:

$T\,c$ = foot pounds in reaching elastic limit of tension.

$T\,r$ = foot pounds to produce rupture by tension.

$T'c$ = foot pounds in reaching elastic limit of compression.

$T'r$ = foot pounds to produce crushing.

"One-half the weight into the whole extension, or the whole weight into half the extension, is adopted, because the force gradually applied to break the bar must increase from nothing to the breaking weight. Upon Dr. Hooke's law, *ut tensio sic vis*, the weight of a grain will, in some minute degree, deflect or extend the heaviest bar of iron, and the deflection, or extension, will increase progressively with the weight applied, up to the point of rupture. Therefore, if a bar be stretched one foot and then broken with a weight of 33,000 pounds, the work done will be the mean of zero and 33,000 pounds into one foot, or 16,500 pounds. This, as has been said, is the work done in the case of a gradually applied strain. If, however, the weight be applied without impact, yet instantaneously, upon the bar, it will, so long as the limit of elasticity be not exceeded, and supposing the bar to have no inertia, produce twice its former deflection and, therefore, twice the ultimate strain. For the weight, in falling through the distance of the deflection due to the load at rest, will require momentum sufficient to carry it through an additional distance equal to the static deflection. This may be best demonstrated experimentally with the aid of a spring balance. If upon the pan of a balance, sufficiently strong to weigh up to 40 pounds, a weight of 15 pounds be placed, and this be lifted to zero on the scale and there released, it will descend momentarily to nearly 30 pounds on the scale, and were there no opposing resistances, and had the spring no inertia, it would descend to exactly 30 lbs. In the actual application of strains in practice a weight is never thus applied, but a consideration of what would occur under such circumstances is sufficient to show how important it is that vibratory action be not overlooked in considering the strains on bridges. It is to be remembered that this action of suddenly applied loads is only manifested in the case of the application of weights, for if the strain be produced by the sudden admission of steam, or any other practically imponderable body, no additional deflection will take place beyond that due to the pressure acting statically. If steam pressure acted in the same manner, in this respect, as a weight, the steam indicator would show nearly, or quite, double the pressure acting effectively within the cylinder of the engine."

It will not be attempted in the present paper to discuss fully the co-efficients adopted by Mr. Mallet, for there are objections against, as well as reasons in favor, of their application. It is evident that T *r* may be the same in two cases, in one of which a high breaking weight is exerted through a very short distance, and in the other of which a low breaking weight produces stretching through a correspondingly greater distance. But this co-efficient does possess a value in taking account of the combined cohesive force and extensibility of iron, instead of the breaking strength alone. Glass has a high cohesive force, but is uselcss under strain, on account of its brittleness, while india-rubber has great extensibility, or toughness, with but slight cohesion. The products, therefore, expressed by the co-efficients in question do not afford a complete notion of the practical value of a given material, unless the factors whereby these products are obtained are also given. The elastic limit of iron, however low, is not to be exceeded in practical use, whatever its range of elasticity may be; nor does it appear to be prudent to work into the neighborhood of a high elastic limit, when the elastic range is known to be small. It is not to be understood that the co-efficients in question are intended to be applied otherwise than in the comparison of bars of equal length, else it would result that the measure T *c*, in a bar 50 feet long, was one hundred times greater than that of a bolt six inches long, and of the same material and sectional area. For the purposes of the engineer not only is a long bolt no stronger than a short one, but, as it can be no stronger than its weakest part, it will follow that the average strength of 100 bolts six inches long is likely to be greater than that of a bolt of the same diameter 50 feet long. Every engineer is aware of the importanee of toughness in combination with cohesive strength in iron, but we need much more extensive and accurate information respecting the former; and a consideration of Mr. Mallet's co-efficient should lead to additional experiments being undertaken.

Mr. Kirkaldy, proceeding upon an independent course of inquiry, but with the same object as that pursued by Mr. Mallet, published some time ago the results of a series of experiments, which are the first upon any thing like an extensive scale, to take into account the combined cohesive force and extensibility of iron and steel. Mr. Kirkaldy experimented upon hundreds of specimens; but he did not ascertain their limits of elasticity. He has given both the original dimensions and cross-sectional area, and the dimensions and area after fracture, and he has also given the amount of elongation at fracture, although he did not ascertain the amount of extension at the elastic limit. The reduction of diameter of a bar at the joint of fracture serves to give a practical man a good idea of the quality of the iron, but it does not admit of an expression of the mechanical work done in producing fracture, as does the combined breaking weight and linear extension. In tearing a bar in two, also, we have to consider the permanent stretch communicated to all parts alike, and the additional stretch at or near the point of fracture. That part of the stretching which extends uniformly throughout the bar would, we may suppose, be exactly proportional to the length of the bar, while that part of the stretch which takes place close to the point of fracture would, we may also suppose, be a fixed quantity, whatever the length of the bar. Mr. Kirkaldy's specimens of iron and steel varied from 2.4 inches to 8.2 inches only in length, and with these the ultimate elongation at fracture varied from nearly nothing to 27 per cent of the original length, whereas longer bars would have shown a proportionally less elongation. The samples which hardly elongated at all were of puddled steel ship-plates. One sample, which bore 63,098 pounds per square inch of the original area, stretched before breaking but the $\frac{1}{20}$th part of an inch in a length of 7.6 inches, or less than $\frac{7}{10}$ths of one per cent of the length. Adapting to Mr. Mallet's co-efficient, the structural value of such a material would be almost nothing. In fact, Mr. Kirkaldy found the puddled steel plates throughout to have much less extensibility than cast steel plates, and of very irregular breaking strength.

Mr. Fairbairn communicated some of the results of an important series of experiments to the British Association at the Manchester meeting in 1861, from which it appeared that a large model of a wrought iron plate girder withstood, without injury, 1,000,000 applications of a load equal to one-fourth its breaking weight, and afterwards 5,175 applications of one-half its breaking weight, when it broke down. The model was then repaired, and 25,900 applications of two-fifths its breaking weight, and afterwards nearly 3,000,000 applications of one-third its breaking weight were made, it is said, without injury.

The application of iron to bridges, especially to those of large span, necessarily requires the most careful consideration in apportioning the strains, since every pound of metal not brought into effective action is so much dead weight, or useless load, being not only misapplied of itself, but requiring additional material to support it.

The practice among American engineers is very uniform. The factors of safety are almost invariably as follows: For parts subject to constant strain, six; and for parts subject only to occasional strains, four. These figures are factors of *ultimate* strength. The margin of safety has, in all cases, been ample so far as we can learn.

TRACTION ENGINES.

From "The Engineer."

Although the very first carriage ever propelled by steam was constructed years before railways were thought of, and, as a natural consequence, made the first tottering essay at mechanical locomotion on a highway, common roads still remain almost unavailable as a means to locomotion by engine power. A very few years since—a dozen, let us say—an idea sprang into existence that every portable agricultural engine might be, ought to be, and would be made self-propelling, while very large numbers of engines, specially designed, not to drive threshing machines or ploughs, but to haul loads, would be built. Gentlemen like Bray and poor Boydell fostered this idea, and threatened the railways. The railway companies paid not the least attention to the matter. It could be easily proved, they thought, that steam on the common road would never beat steam on rails, and in a sense—and a large sense, too—it is certain that railway companies and their engineers were right in this conviction. The rage for traction and self-propelling engines died out. At this moment it is probable that a smaller number of traction engines is in use than at any other period within the last six or eight years. The number of self-propelling engines—that is to say, of engines intended to take themselves and a plough or threshing machine from farm to farm—is probably much greater, but it must be remembered that from these latter machines railway companies have nothing either to hope or fear; they add not at all to facilities for locomotion, and their abundance or scarcity does not affect the great problem of transporting heavy goods or materials on common highways by using steam instead of horses. With limited exceptions, the traction-engine system has proved a complete failure. It is true that hundreds of traction engines have been built here and elsewhere, and sent to all parts of the world and put to work, and have remained at work till worn out. But this fact is of the smallest importance. If the traction engine had been a success, it would have done for horse haulage what the locomotive did for the stage coach. Instead of hundreds of traction engines we should have built, sent away, and put to work, thousands.

No one disputes that steam might be employed with great success on common roads as means of cheapening the transport of heavy goods or materials of all kinds, such as corn, timber, coal, ores, lime, bricks, and such like; but neither does any one dispute, so far as we are aware, that steam is not so employed either here or abroad, except in a very small and insignificant way, with success. When it can be predicated by intelligent engineers that a given machine ought to succeed, while it can be proved that it does not succeed, a problem is presented, which we, as technical journalists, are bound to consider, and if possible to solve. Let us attempt, then, to solve this question, bringing, we may add, without overstepping the bounds of editorial modesty, at least a little practical experience in traction engines to bear on the matter in hand.

It is very commonly urged that traction engines are not more commonly used because the law concerning them is harsh, repressive, and almost prohibitory. Now even if we granted this statement to be a statement of facts—and we do not—it proves very little for the traction engine builder. It is true that the law prohibits a greater speed than four miles an hour, and orders that each engine shall be preceded when on the road by a man with a red flag, etc. But, in the first place, this rule is not very oppressive, and, in the second, engineers have only themselves to thank for its existence. Traction engines, as they are, are unutterably hideous, astoundingly noisy, and to the last degree offensive in the matter of smoke—not only to horses, but to men. If it could be proved that these conditions are inseparable from the system, then we should have small hopes indeed of the ultimate success of steam on the highway. We believe, however, that the ugliness, noise, smoke, and general nuisance, all result from the great fact that those who have built traction engines up to the present moment have not realized the importance of getting rid of the specified objections—or, realising it, have been unable to design engines of better construction. A glance at the contents of any agricultural show will prove that the ruling principle guiding the makers of traction engines is to take the ordinary portable engine and adapt it to drive a pair of road wheels. As a result, we have an engine without springs and with all the gearing exposed to the broad glare of day, thumping, and clanking, and grinding, and smoking along our highways. The thing is a nuisance, an unmitigated nuisance, and it is folly to deny the fact. Worse than this, the nuisance is continually getting not only its owners but itself into trouble by breaking down; and all this because a machine specially designed for one purpose is applied to another.

Without engravings it would be impossible to show what a traction engine should be. Perhaps our portfolio of working drawings may yet include one design, disposing of most, if not all, the objections concerning smoke, noise, ugliness, and breakdowns. For the present we shall content ourselves with indicating a few of its features. We have stated that traction engines as they exist are a nuisance, and this in itself is one very sufficient reason why steam on the common road is not a success; but one or two others of even more importance remain to be considered. The first is, that, all things considered, traction engines do not compare favorably as regards the cost of the work done with horses; the second is, that they consume large quantities of water, which cannot always be had, and that even when it can be had, much time is wasted in taking it in. Four miles an hour running time, in all cases becomes three miles an hour including stops to take in water. We have now put before our readers, in one way or another, most of the objections to traction engines. Let us see how they are to be got over.

In the first place, a radical change must be made in the arrangement of the entire machine as compared with those now in use. Instead of the portable engine, we must take the railway locomotive as our model. The first point to be settled is the construction of the machine regarded as a carriage. As the road to be traversed is rough, and machinery does not like rough roads, the two must be kept apart as far as possible. Therefore instead of mounting a boiler half full of water on rigid wheels without the interposition of springs, and a heavy, quick-running engine and fly wheel on top of the boiler, we must provide a rectrangular frame of iron or of oak between iron plates. The frame must be supported on wheels—preferably of wood—through the intervention, not only of springs, but of perfectly efficient and elastic springs, with india-rubber buffing-pieces to take up the last trace of jar and vibration. Next we have to provide a crank shaft running in brasses fixed in wrought iron cheeks—no cast iron except that in the cylinders and a little in the gearing should be allowed in a traction engine—which crank shaft must be driven by a pair of pistons, in order to get rid almost or altogether of the fly wheel—and unnecessary and objectionable excrescence, which should have no more place on a traction engine than it has on a locomotive.

The next step is to provide means by which the crank shaft when revolving will cause the hinder wheels to revolve also. For this there is nothing like a chain, only the chain must not be run too fast, must have plenty of bearing surface, and must admit of being tightened when it gets slack. Various modification of the chain may be used, but we will not stop to consider these just now. If the engine is intended to run at slow speed with heavy loads, intermediate gear must be employed. On the crank shaft a pinion is to be placed gearing into a spur wheel about 3 to 1, and the shaft of this spur wheel—lying across the frames in the rear of the crank shaft—will carry a small chain wheel, while a large chain wheel will be fixed to the boss of one of the road wheels, either or both of which will be fixed at pleasure to the axle. When moderate speeds are allowable the chain pinion may be fixed direct on the crank shaft, which may make nine revolutions for one of the road wheels. If these last are a little under 6 ft. in diameter they will revolve about 288 times per mile, or, at five miles an hour, twenty-four times per minute, which gives 216 revolutions per minute for the engines, the cylinders of which should not be too small in diameter. Ordinarily, steam will be worked expansively in them. By admitting it full stroke, sufficient power may be developed to get the engine up a steep hill or out of a difficulty, at least such a difficulty as will be encountered on a good road—and five-mile an hour engines should not work except on good roads.

The character of the boiler and the position of the cylinders remain to be settled. In any case the crank shaft should be placed as nearly as possible on a level with the road axle—why, we shall not stop to explain. If the locomotive type of boiler be used, then the clinders go into the smoke box; but under certain circumstances it will be found best to use a vertical boiler placed at one end of the frame, while a water tank is placed at the other, the cylinders being placed vertically between. The use of vertical cylinders will not induce much jump, if any, in a heavy engine; and by adopting the vertical instead of the horizontal arrangement one great difficulty is disposed of. The cylinders and engine can be put near the ground and yet remain accessible and out of the dirt. All the machinery must be boxed-up out of sight.

We have yet to get rid of the waste steam and the smoke. By taking the exhaust through a superheating pipe in the furnace the waste steam may be rendered invisible, and the noise may be completely obviated by discharging from the cylinders into a receiver. As regards smoke, that must be got rid of by the use of coke.* We are unacquainted with any other expedient which will *effectually* prevent the evolution of smoke from the small furnace of a traction engine. Its compulsory use would be no great hardship.

* Or in America by the use of anthracite.

THE SPECTROSCOPE.

From the "American Exchange and Review."

That ordinary or white light may be decomposed by refraction into what are commonly known as the "colors of the rainbow," is a familiar fact. Every transparent substance of greater density than that of air, and bounded by surfaces inclined to one another, gives evidence of this dispersion, as the separation into color is technically called. We see it in the drops that fall from the clouds, in the flashing hues of the diamond, and in the pendants of chandeliers; but it is most conveniently and perfectly exhibited by what is called a prism—a piece of glass having two surfaces greatly inclined to each other. Light, after passing through any of these dispersive media, is no longer of simple and uniform whiteness; it is transformed into a series of the most vivid and delicate tints, melting into each other by an insensible gradation, from a dark heavy red, through brilliant orange, green, and blue, to a deep and tender violet. We are not now concerned with the inquiry, how this diversity of hue is universally found where refraction, or bending of the rays of light, takes place; and whether color is so connected with refraction that every progressive degree of refraction produces its own tint, in which case each hue would be simple and independent; or whether some, at least, of the colors may not be of composite character. The question now seems to lie between a superimposition of three bands of the colors recognized as primaries in painting—red, yellow and blue—equal in extent, but very unequal in intensity in different parts of their length—and a continuous series of literally innumerable hues, each equally elementary and self-subsistent, and each passing, without the least overlapping, into its neighbors on either side by the most delicate and imperceptible modification.

The spectroscope, an instrument invented by Frauenhofer, is destined to take rank with the telescope and the microscope as a revealer of mysteries. Its structure is sufficiently simple, comprising, as its essential parts (for the details are subject to much variation), a slit of adjustable narrowness between two metallic plates, to eliminate the overlapping of the spectra; a prism, or rather, in order to obtain a wider dispersion, a combination of prisms, to decompose the admitted but straightened ray; and a small telescope, the intention of which is to magnify the spectrum thus formed, and rendered sufficiently pure to exhibit its interior arrangement, so as to unfold more effectually its complexity. The investigation conducted by means of this beautiful apparatus is known as spectrum analysis, and it is equally applicable to every kind and degree of light, provided it retains sufficient intensity, after this unsparing reduction and expansion, to form a distinct impression upon the eye.

With the light given out by the terrestrial elements raised to incandescence, a vivid spectrum at once streams from the prism. Any solid element thus ignited affords a band of brilliant colors, but without the crossing of a single dark line. Urge it until it flows down in fusion, still the unbroken spectrum remains; but force on the heat till the material rises into a glowing vapor, and the scene is changed. At once the continuous spectrum, the uninterrupted stream of color, common to every ignited solid or fluid element, is converted into a succession of transverse lines, brilliantly and variously tinted according to their place in the spectrum, extremely narrow fragments, as it were, of the continuous spectrum, and separated by intervals, more or less wide, of darkness—gaps where that spectrum has totally disappeared. This is strange, and in its first impression strangely irregular; but further examination shows us a yet stranger regularity. There is no rule as to the thickness or position or grouping of the bright lines, but we shall find that every chemical element, whatever its nature, has, when in a state of vapor, a system of lines of its own, and so peculiarly appropriate to itself that the appearance or non-appearance of those lines is an infallible criterion of the presence or absence of that element.

The spectrum, as the band of varied hues is called, when obtained direct from the sun by refraction—whether naturally, as through the bow set in the cloud, or the rain drops pendant on the leaves, or artificially, as through a prism of glass or other suitable material—exhibits nothing more than a succession of brilliant tints passing gradually from red of various qualities, through yellow and green, to blue, deepening into violet. But a little consideration will show us that these colors, however compounded in their own nature. cannot under these circumstances be regarded as absolutely simple and pure. They would be so if the sun were a point; but the breadth of its surface, or, in astronomical language, disc, prevents the complete analysis of its light; for every portion of this disc, from the one side to the other, in whatever direction the refraction may have been effected, has been contributing its own share of light to every portion of the spectrum, so that the latter, instead of being a simple decomposition of one pencil of light issuing from one point, is an overlapping, to a certain small but not inconsiderable degree, of innumerable spectra from an infinite number of luminous points, producing a confusion, the limit of which is, of course, the apparent breadth of the source of light. Within that confusion, that crowding together and intermixture of neighboring tints, some mystery may lie concealed, and fortunately the means are ready to our hand to explain it. We can thin out the crowd to a simple rank by reducing the visible breadth of the sun to a single point. Or, better still, since the tints are mingled and confused only in one direction, that of the refraction, we may, by means of a slit which can be adjusted to any amount of opening, narrow the sun's disc to a mere transverse line of light, which, preserving the full breadth of the spectrum in its own direction, and giving us, as it were, a ribbon dyed in transverse bands instead of the single parti-colored thread which would issue from one point of light, makes the phenomenon conspicuous enough for study, while the confusion arising from overlapping is removed. Thus formed from a single narrow transverse streak of light, the spectrum is no longer a continuous band; its colors remain as they were, but it is full of interruptions; it is crossed in innumerable places—the best instruments show upwards of 2,000—by dark lines, some much broader and more conspicuous than others, but all of hair-like minuteness, and in most irregular arrangement and fortuitous grouping.

The spectrum of the sun is discontinuous, with hair-breadth tracks of darkness. The spectra of the terrestrial elements are also discontinuous, but with hair-breadth lines of light. The one seems of a class which is the reverse of the other; but this apparent contrariety will lead to further thought and further investigation.

The discovery of the true meaning of the solar spectrum, in 1859, was the commencement of a long series of discoveries in solar physics. It had long been noticed that the rainbow-colored streak of light which forms the solar spectrum is crossed by a multitude of dark lines. Some of these lines are well marked, others faint; at one place many are crowded together, at others there are scarcely any; but at all times the same lines make their appearance. For a long time this phenomenon remained without explanation, as also did the correlative phenomenon that the spectra of incandescent vapors consist, not of a rainbow-colored streak, but of a definite number of bright lines. But Kirchhoff, in 1859, made the important discovery which forms the basis of spectroscopic analysis. He found that the dark lines in the solar spectrum correspond to the bright lines of the spectra of incandescent vapors. For example, the double orange line which forms the spectrum of sodium vapor occupies exactly the same place as a well-marked double dark line which appears in the orange part of the solar spectrum; and so with many other similar lines or sets of lines. In fact, he demonstrated that the presence of dark lines in the solar spectrum indicates that the light of the sun shines through a vaporous envelope, and that the vapors which form this envelope are the same which, in an incandescent state in the chemist's laboratory, produce the bright-line spectra corresponding to certain of the solar dark lines.

To sum up in a few words those principles of spectroscopic analysis which are our chief guide in solar researches: An incandescent solid or liquid gives a continuous rainbow-colored spectrum; an incandescent gas gives a spectrum of colored lines; and an incandescent solid or liquid shining through a vaporous envelope gives a rainbow-colored spectrum crossed by dark lines, and these lines have the same position as the bright lines which belong to the spectra of the vapors which form the envelope.

THE PARIS STEAM ROAD ROLLER.

From a paper read before the Institute of Mechanical Engineers, by Mons. M. E. Gellaret.

This roller consists of a locomotive engine carried entirely upon two large cast-iron rollers of equal size, which are both driven by the engine, the course of the machine being controlled by a special arrangement for changing the direction of the roller axles. The result is that the whole of the weight of the machine is made available both for the rolling of the road and for propelling the machine. The engine is capable of being readily started in either direction without any slipping, and can easily round very sharp curves. This machine is the only one which allows all the weight to be made available for adhesion in driving—an indispensable requisite for a really complete rolling machine—none of the weight being dragged; and machines having only one axle driving are liable to slip at starting, causing damage to the road surface to be rolled, and wasting power. Also, the direction of the motion, whether forwards or backwards, being entirely indifferent, is another essential point for rolling roads. By a special mechanical arrangement the communication of the driving power is maintained direct to both the rollers, however much they may be inclined to each other when traversing a curve; this driving apparatus is made very strong and durable, and it has been found completely successful in work. The weight of the machine is equally divided on the two rollers, and the adhesion for driving is so great that these machines have worked up hills with a gradient of 1 in $12\frac{1}{2}$. They are guided with the greatest facility and certainty on the most difficult and winding roads, by the axles of the rollers being made to converge to the centre of the circle which is being traversed. These machines have now been in regular use in Paris for four years, and the results of their working have so thoroughly established their durability and economy that they are used for the whole of the roads in that city and the suburbs. The machine has a longitudinal wrought-iron frame, like a locomotive engine, with cross bearers to carry the boiler, and a water tank at the back of the footplate. The two large carrying rollers are 3 ft. 10 in. in diameter, and 4 ft. 7 in. in length. They are cast-iron cylinders of $1\frac{1}{2}$ in. thickness, with intermediate strengthening ribs and internal flanges at the ends, to which wrought-iron plate covers are fixed. These close the two ends of the rollers, and have cast-iron bosses in their centres for bearing on the axles. The axles are stationary, and the rollers revolve round them with bearings extending the whole length of the roller, and consisting simply of a cast-iron cylinder, with a continuous bearing on the axle, and furnished with a spiral groove for lubrication. The rollers in the first of these machines were made with separate wrought-iron wheel centres, upon which was riveted a cylinder of boiler plate; but this make was abandoned in consequence of the frequent failure of rivets, which were sheared off by the stretching of the cylindrical plate from rolling out. The present make of cast-iron rollers, heavier than the original wrought-iron ones, but less expensive in make, has proved very satisfactory, and they have done a large amount of work without any expense for repairs, some of them having run as much as 3,000 miles without any sign of cracking or splitting. The first cast-iron rollers were made quite cylindrical; but it was found that the surface became worn down more at the end next the chain-wheel than at the other end; and to meet this irregular wear the rollers have since been cast slightly conical, with the larger end towards the chain-wheel, so that when half worn down they may become truly parallel. One end of each roller has a manhole in it, giving access to the interior for oiling the bearings. There are two sizes of these machines used in Paris—one weighing 15 tons and the other 30 tons in average working order. The smaller one has rollers 3 ft. 11 in. in diameter and 4 ft. 7 in. in length; the rollers in the larger one being 4 ft. 9 in. in diameter, and 6 ft. length. These machines were adopted for rolling the roads in Paris, in consequence of the satisfactory results of a series of experiments made with them under the direction of M. Michal, director of the municipal service, by M. Homberg, engineer-in-chief of the public roads of Paris. The machines are hired at a fixed charge, which is regulated by the weight of the machine and the distance run in work; the rate being per ton per mile of the machine, 7d. by day and 8d. by night. This rate includes all expenses of wages, coals, and materials for working and repairs, excepting the supply of water, which is furnished by the municipal authorities. The work of each machine is measured by a self-acting counter, indicating the distance traveled, measured at the mean diameter of wear of the rollers; the measurement of distance being taken only during the actual time of rolling, with an allowance added of three miles for traveling to and from the place of work. The work is, as a general rule, done in the night within the city, the portion of road repaired during a night being completely finished by the morning ready for traffic. The speed of working is from $1\frac{1}{2}$ to $2\frac{1}{2}$ miles per hour, being limited to the latter amount by the public regulations. The usual practice in repairs is to lay down a layer of broken stone about $2\frac{1}{2}$ in. thick at the sides of the road, and 6 in. thick in the middle; the surface of the road being generally picked up previously. The rolling engine commences work at the opposite sides of the road; alternately traveling backwards and forwards over a length of about 100 yards, and working its way gradually to the middle of the road, when it proceeds to roll another similar length. The layer of broken stones is watered from the street mains, and binding material, consisting of road scrapings, is put on before the rolling. There is not the slightest difficulty experienced in reversing the motion of the rolling engines, and they start in either direction without any slip whatever, and the broken stone is regularly rolled down without getting pushed up or driven before the rollers. The engines start with great facility, even on a considerable incline, and they turn easily in a circle of only 13 yards radius. In making new roads the broken stone is usually laid down in a single layer of 10 to 12 in. in thickness, and this thickness of material can be satisfactorily rolled. The total distance traveled per day of ten working hours by one engine is usually from 15 to 20 miles. In working, two men are employed for the smaller engines—an engineman and a steersman, and for the larger engines a fireman in addition, for the purpose of oiling upon the road without stopping the engine. The mean power developed by the larger engines is about twenty horse power. It is often below that amount, and then sometimes rises to thirty or even thirty-five horse power. The engines keep well in order, and run from 1200 to 1800 miles before requiring any important repairs. They are made very strong; the axles, chains, pinions, and working gear being made of steel, and the engines of the quality of best locomotive work. They are consequently expected to keep at work fully ten years. In reference to the relative cost of rolling roads by the steam roller or by horse power, the following facts may be taken as a comparison of the prices per ton per mile by each plan. The result of numerous data shows the cost of horse rolling in Paris (including horse keep, drivers, and oiling) to be 11d. per ton per mile, or about $11\frac{3}{4}$d. including cost of repairs. The addition of interest of capital and depreciation would raise the total cost to about 14d. per ton per mile. On the other hand, for the steam rolling the actual payment is only half that amount, or 7d. per ton per mile, including the contractor's profit; so that there is a great economy as regards cost of power in the steam roller. The advantages of the steam roller over those drawn by horses are, economy in the cost of the work, rapidity of execution, and greater perfection in the work done; the durability of the road surface being found to be at least doubled where the steam rolling has been well done, as compared with roads not so rolled.

On the Influence of Severe Cold on Metallic Tin.—Fritzsche, of St. Petersburg, communicated to the Paris Academy the interesting fact that during the severe cold of last winter, in St. Petersburg, large blocks of Banca tin became crystalline through the whole of their mass. They now contain in their interior, hollow spaces of up to 100 cubic centimeters. The walls of these hollow spaces are smooth and shiny. The other parts of the tin which have been transformed partly into small crystalline grains, partly into brittle pieces of various sizes, have a dull appearance, caused probably by superficial oxydation.—(*Compt. Rend.*, t. 67, p. 1106.)

LIGHT VS. HEAVY LOCOMOTIVES.

ROLLING STOCK ON THE METROPOLITAN RAILWAY.

From "The Engineer."

Those who are interested in the often-discussed merits of light *versus* heavy rolling stock, will find just now much deserving of their attention in the working of the Metropolitan Railway. They may there see some of the lightest tank engines and carriages recently used for main line traffic, working side by side with the heaviest stock ever put on any line. A very important problem, therefore, bids fair to receive a speedy solution on the Metropolitan Railway; and the solution will, unquestionably, possess every characteristic which can render it absolutely final under the prescribed conditions. In a word, a most valuable experiment is being tried on the largest scale; and the result, be it what it may, must be accepted as conclusive. The facts may be stated in a very few words, but they will be all the better for a little explanation.

The first engine designed to work the Metropolitan Underground Railway, was fitted with air pumps and an injection condenser. Its weight was something enormous, and its performance so unsatisfactory that we believe it never ran a single passenger train. The line was first practically worked by the Great Western Railway Company with broad gauge engines, having outside cylinders and six wheels, four of them being coupled. These engines did very fairly, and are now in use down the country. Next came an interregnum, when the traffic of the line was conducted by the Great Northern Railway Company with their ordinary narrow gauge mixed engines, blowing their waste steam into the tender through a temporary exhaust pipe. Meanwhile, Mr. Fowler prepared designs for new narrow gauge tank engines. These engines being specially designed to work underground, possessed not a few novel features. Twelve were built in the first instance by Messrs. Beyer and Peacock, and, as a natural consequence, the work is simply faultless. We cannot say as much for the design. It was of the utmost importance that the engines should get away quickly with their trains, yet the driving wheels are 5 ft. 6 in. in diameter, a dimension rendered inexcusable by the fact that only a moderate speed was demanded. In order to compensate for the size of the wheels, and to still retain the great tractive force, essential to rapid starting, large cylinders were of necessity adopted. We need not stop to explain how great an augmentation of weight this entailed. It was next assumed that the curves would be bad to get round with a six-wheeled engine, therefore a bogie was introduced principally because the engine was made too long to begin with. This farther increased the weight, and so, finally, Mr. Fowler produced the now well-known narrow gauge standard Metropolitan engine, weighing nominally 42 tons, but in all probability at least 45 tons loaded. This monstrous machine is employed to haul trains consisting of five not less monstrous carriages, carriages mounted on eight wheels disposed in two groups, and weighing 16 tons each. We have thus a locomotive weighing 45 tons hauling a train weighing 80 tons, carrying, when full, 20 tons of passengers or so, at a speed of 25 miles an hour, over the best permanent way ever laid down: gross load, 155 tons; paying load, 20 tons, or less than half that of the engine alone. There are no exceptionably heavy inclines to be surmounted, and the bad curves are few in number, and at the worst do no great harm, because the speed at which they are traversed, as at King's Cross, for example, is low. We fancy that every unprejudiced engineer, with these facts before him, will admit that Mr. Fowler's engines are not the best that can be designed for the intended purpose, and that, all things considered, they are apparently very much underworked. The driving wheels are much too large, the machine too long, and, above and beyond all, the enormous weight of the engine constitutes a grievous defect. There is no denying the fact that the standard engines play havoc with the permanent way of the Metropolitan Railway, smashing off the tables of steel rails, and grinding out the best Bessemer track, perhaps in the world, as though it were made of iron.

Mr. Fowler has gone on adding to the original stock of twelve engines with others built off the same patterns; but we find that neither the Great Northern, the Midland, nor the Great Western Companies have followed his example. The Great Western Company put on some broad gauge engines with six very small coupled wheels and inside cylinders, three or four years ago; these have been abandoned with the broad gauge. The Great Northern Company, in working steeper inclines than any which the Metropolitan engines are called on to traverse, adopted a design differing widely from Mr. Fowler's. The Great Northern engines weigh full but 33 tons. They have four coupled wheels, 16-in. cylinders, and a pair of trailing wheels mounted with Adams' radial axle boxes. These engines gave great satisfaction. Next came the Midland with a modification of Mr. Fowler's design, the engines weighing much less, however. And, lastly, we come to the rolling stock put on by the Great Western Company within the last few months, which is the very antithesis of Mr. Fowler's. Now, if the designs of the latter gentleman had been proved to be right by the results of three years' working, how is it, we may ask, that the engineers of other companies have not followed his example or endorsed his practice by adopting his typical engine and carriages? The fact that they have not, is the best possible proof that Mr. Fowler made a great mistake when he designed his standard rolling stock for the underground railway.

We do not propose here to say anything more of the methods adopted by the Midland and Great Northern Railway in working their metropolitan traffic. We shall confine our attention to the new engines and carriages used by the Great Western Railway Company in working their local traffic between Windsor, Ealing, &c., and Moorgate street, since the abandonment of the broad gauge between Bishop's road and the City. The engines resemble those used by the Midland Company in working their metropolitan traffic, but they are rather smaller, and certainly more elegant. They have flush boilers with a very small central dome, a pair of side tanks, and a condensing arrangement very similar to that used in the standard engines. They have six wheels, four of them being coupled, and inside cylinders. These engines weigh full, one with another, as nearly as possible $32\frac{1}{2}$ tons, or from 11 to 12 tons less than Mr. Fowler's engines. The average train drawn consists of six light carriages, but this in no way represents the capacity of the engines. In the early part of the day the trains are much longer; and on several occasions fourteen carriages have been taken from Windsor to Paddington, a distance of about eighteen miles, in a little over twenty minutes. We have carefully timed these engines when getting away with their trains, and found them to be quite as expeditious as Mr. Fowler's engines, perhaps a little more so. In every respect their performance is most satisfactory. We have, then, in few words, the Great Western Railway Company doing the same work that the Metropolitan Railway Company are doing, with a dead weight less at least by 25 tons per train, if we assume ten of the Great Western carriages to carry only as many as five of the Metropolitan carriages.

It remains, of course, to be seen how the Great Western light stock will work out in continuous practice; so far, it leaves nothing to be desired. The carriages, though small, are lofty and comfortable; they are not as yet disfigured by hideous advertisements; perfect time is kept, and a carriage or two being easily added or taken off, as may be necessary, the trains are, as a rule, fairly filled, without being overcrowded. If Mr. Fowler's method of working metropolitan traffic can be made to pay—and it is—then much more should the Great Western system pay. In the case of the engines alone, the cost of transmitting each ton of dead weight from place to place cannot be much less than 2d. per ton per mile. Taking the very moderate estimate of 20,000 miles as the distance run each year by each engine, we have a saving on 12 tons less in the Great Western engines, as compared with the standard Metropolitan engines, of £166 per engine per annum, or for the Metropolitan Railway Company, with 36 engines, a saving of, in round numbers, £6,000 per annum; while, if we regard the smaller weight of the carriages, and the increased durability of the permanent way, due to the use of light rolling-stock instead of heavy, we shall find that the saving may possibly reach double the sum we have named.

CAST-IRON FORTS.

From "Engineering."

In these days of Shoeburyness trials, when almost every conceivable combination of iron and steel capable of forming a target has been subjected to hammering by shot and shell, with more or less satisfactory or unsatisfactory results, it is something to come across the proposal of a really novel, and at the same time promising, system of fort construction. We have had shields formed entirely of wrought iron, shields of iron with wooden backing, shields of iron and steel, granite casemates with iron shields, and a host of other devices, and now we have Mr. Thomas R. Crampton's proposal to make forts of cast iron. Not a very promising material some of our readers will say; and we must own that except it be employed in the way Mr. Crampton proposes, they are right. The proposal to use cast iron as a material for constructing shields or defences is not new, and Mr. Crampton lays no claim to it; but what he does claim is the plan of constructing forts by casting them *in situ*, either in one single piece or in blocks of large size, each weighing not less than 200 tons or so. Forts thus constructed would afford very different resisting powers to defences built of cast-iron blocks weighing three or four tons each, such as have been in some cases proposed; and although we have no data from which we could calculate what the resisting power of such massive blocks as Mr. Crampton proposes to use would be, we are, we think, justified in stating that the system is worthy of a trial.

That there would be no great practical difficulty in constructing such forts is certain. The process would be merely an extension of that which has been so successfully carried out by Mr. Ireland in a number of instances, when large anvil blocks have had to be cast. All that would be requisite would be to prepare the necessary foundations, and construct *in situ* a mould of the required form, this mould being either made of brickwork, or of a combination of brickwork and iron framing, according to the circumstances of the case. Around the mould would be arranged, in convenient positions, a series of cupola furnaces, the number of these furnaces being regulated by the size of the casting to be produced and the time allowed for completing the operation. Mr. Ireland has, as we have said, produced a number of large castings by a similar method, and about eighteen months ago (*vide* page 496 of our fourth volume) we described the casting in this way of an anvil block weighing 210 tons at the Bolton Iron and Steel Works. The metal for this block was run from two cupolas in $8\frac{3}{4}$ hours actual working time, and the casting proved perfectly successful. Judging from the experience already gained, there appears to be practically no limit to the size of the castings which can be produced on this system, and we feel certain that Mr. Crampton would have no difficulty in casting his forts, as he proposes, in solid blocks, weighing 5,000 tons or so, if occasion should require it.

We have said that we have no data as to the resistance to shot afforded by cast iron in large masses; but we are inclined to think that it would be satisfactory. Mr. Crampton, however, does not confine his plan to the application of cast iron alone; but he states that the metal may be strengthened by melting up scrap iron with it, or in some cases the castings may be formed of steel or iron produced by the Bessemer process. Whether it would be possible to apply the Bessemer process to the satisfactory production of such gigantic masses we cannot say, but we have no doubt about the possibility of producing them in plain cast or toughened cast iron. In the case of the cast-iron forts being of such form as to require portholes, Mr. Crampton proposes to guard each opening by the insertion in the casting of a massive block of wrought iron or steel of suitable form.

As for the expense of constructing such forts as we have above described, Mr. Crampton estimates that a cast-iron structure might be made six or seven times the thickness of a built-up wrought-iron structure of the same total cost; and considering the high price of heavy wrought-iron armor plates, we do not think that this estimate is an unreasonable one. All events, we think that our government authorities might do many worse things than test the effect of shot and shell on a 200-ton block of cast iron.

LIQUID FUEL IN METALLURGY.

From the "Mechanics' Magazine."

The advantages of liquid fuel, when properly used, over coal, for steam purposes, have long since been fully demonstrated, and they stand unquestioned. Hitherto, the endeavors to utilize mineral oils have been chiefly confined to the furnaces of boilers; but now we have another eminently successful application of the oil furnace to metallurgical purposes. Our readers can hardly have forgotten the successful trip of the "Retriever," a steam ship of 500 tons burden, which was fitted up on the system of oil furnace invented by Mr. Dorsett, of London.* This system consists in burning in the furnace the vapor of creosote, which is produced in an auxiliary boiler. Having established the success of the principle in one direction, Mr. Dorsett conceived the idea of utilizing it in another—that of heating iron plates for bending. The idea was first put into execution about four months since, when Mr. Dorsett obtained permission to apply his system of burning liquid

* Van Nostrand's Magazine, No. 1, p. 57.

fuel to a plate-burning furnace in Woolwich Dockyard. This was for plates of the ordinary thicknesses used in iron shipbuilding, and the results were so satisfactory that the authorities directed the principle to be applied to an ordinary plate-bending furnace and to an armor-plate furnace in Chatham Dockyard. It is to the latter of these we wish to direct special attention, as being a great triumph of the Dorsett principle of burning liquid fuel.

Under ordinary circumstances, the armor-plate bending furnace is lighted from four to five hours before the plate is placed in it. The time occupied in heating the plate for bending depends upon its thickness—one hour per inch of thickness being allowed. Taking, then, a 6-inch plate—as upon the present occasion—we get from ten to eleven hours from the time of starting before the plate is ready for bending. Let us now see what the liquid fuel will do. Upon our visit to Chatham, the cold furnace was lighted, and after an hour was deemed sufficiently heated. A 6-inch armor-plate, 7 ft. 6 in. long by 3 ft. wide, was then consigned to the furnace, and after an hour and a-half was drawn out thoroughly heated and ready for bending. Thus, in two hours and a-half we have the work of ten or eleven hours completely and satisfactorily performed. Nor is this all; the advantages of the system do not stop here. The plate was remarkably free from scale, which can only be accounted for by the absence of the deteriorating influence of the products of combustion in the ordinary furnace. Another valuable result arises from this same cause; thinner plates, when heated by liquid fuel and bent double, show no signs of cracking, as they usually do when they have been heated in the coal furnace. This important feature is reckoned to save ten shillings per ton on the metal, which amount it would lose in value by deterioration under the ordinary method of treatment. The vaporized creosote is supplied to the furnace under notice from the generator by six jets, which are led in through small openings, by which means also just a sufficient quantity of atmospheric air is admitted to support combustion. This method of supplying the heat also offers another advantage; it can be applied to the whole or any portion of the plate. Thus, if a plate requires to be bent at one end only, then the heat is directed to that part. Further, the rate at which the metal is heated can be regulated to a nicety by either increasing or diminishing the number of jets. The consumption of oil at Chatham is 108 gallons per furnace per day.

Close beside the armor-plate furnace is another one for heating thinner plates, and which has been regularly at work for some time past. It is heated by four jets, and is supplied from the same generator as the larger one, and which is placed between the two. On the occasion of our visit some half-inch plates were being heated and bent to various templates. The average time occupied in heating was seven minutes; with the ordinary furnace it takes from twelve to fifteen minutes for each plate. As already stated, the heating of the 6-inch plate was only experimental and preparatory to a regular course of practical work which is about to commence. But it was an eminently successful experiment, and, moreover, was not the first made in the same furnace. The plate in question had been through the same process three times previously, although its clean, smooth surface would not have led to that supposition, for it had the appearance of having had nothing done to it since it left the rolls. The future work of the furnace will consist in heating the armor-plates for bending for the "Sultan," a vessel of 5,226 tons burden, now constructing. In this furnace we have another practical evidence of the value of liquid fuel when utilized in the form of vapor. In its working we have some of the most remarkable and unlooked-for results, which, while they fully satisfy us for the present, only lead us to expect further and even more important improvements in the application of the system.

The Bessemer Steel Works at Troy.—The two-ton plant of Messrs. John A. Griswold & Co. is in constant operation, producing some 300 tons of rail ingots per month. The walls and machinery of the new five-ton plant (to replace that destroyed by fire in October last) are nearly completed, upon an enlarged plan. The roofs, furnaces and smaller machinery, are yet to be placed. The new blowing engine, the largest in this country, is nearly ready to run. This company are prepared to take orders for rails for spring delivery, and will be able to execute them upon the completion of the new plant this fall, at the rate of 1,800 to 2,000 tons per month. They are also prepared to furnish rolled bars and shapes in steel, having erected a heavy mill for this special purpose.

ON RIVETS AND RIVETING.

BY MARTIN BALCKE.

Translated for Van Nostrand's Magazine from Polyt. Centralblatt.

The following remarks do not refer to riveting for the purpose of merely uniting two parts of machinery or two sheets of iron, but they apply to rivetings which require a higher degree of strength and solidity, as, for instance, for boilers and working parts of machines. It is a general rule for all constructions, especially for those in iron, to distribute the strain which has to be withstood by a certain part of a machine, as evenly as possible over the solid mass of the said part. This rule is also very important in the use and arrangement of rivets. The simplest and safest way to carry out this rule is to calculate directly the areas of the working sections, and to see that the strain which acts on any part of a section, does not exceed certain limits generally conceded to the respective materials. This is the way, also to avoid the use of empirical formulæ, the most important coefficients of which are always dictated by the personal opinions and notions of their authors.

The force necessary to tear a wrought iron bar of a certain section, is so nearly equal to that required for cutting or shearing the bar, that both may be considered as equal in calculations, for practical purposes. The limit of elasticity of soft wrought iron, as generally used for rivets, is at a pressure of about 18,000 lb. on the square inch. With boilers the strain of tension per square inch of section of the material, ought not to reach 9,000 lb.; because continued heating and long use weakens the material considerably. In the construction of stationary boilers, one square inch of section, taken through the riveting, ought generally not to be strained above 12,000 lb. But if a riveted part of a machine has to sustain a strain acting alternately in two different and opposite directions, this strain should never exceed 2,000 lb. per square inch of section.

If a quite uniform distribution of the strain over all the sections cannot practically be obtained, at least the tension of the sections which are exposed to the highest strains ought to be kept within the above-mentioned limits.

The shape of the head of a rivet is dependent on the kind of strain to which the rivet is subjected. This strain can have the tendency of tearing or of shearing the rivet, or of both simultaneously. If a rivet has to withstand a tearing strain, the height of its head must be such that the cylindrical surface which would make its appearance when the head of the rivet would be stripped off, is equal to the area of a cross-section through the rivet. If we denote the height of the head by the letter h, we obtain the equation:

$$2r\,\pi \times h = r^2\,\pi,$$

which gives us—

$$h = \frac{r}{2};$$

that is, the height of the head has to be one-half of the radius, or one-fourth of the diameter of the rivet.

Practical experiments on the strength of rivets have come to the same result, and have besides shown very distinctly that the rivet-holes should never have sharp edges, and that the head of a rivet ought to be connected with the shaft by a conical part. Whenever this part is omitted, and when, consequently, the rivets have sharp corners below their heads and the rivet-holes sharp edges, the rivets break close to the head, when subjected to a strain of tension and when the heads are strong enough not to be stripped off. When, on the contrary, the rivets have a conical connecting part between their heads and shafts, they extend considerably before they break, and the rupture finally occurs in the middle of the shafts. All experiments have given this result without exception.

Rivets subjected to a shearing strain only, would theoretically not require any head at all. But it is good, also, in this case to make the heads of the rivets as high as above determined, because generally a close contact of the riveted parts is desirable, and because the rivets, being set in red-hot, have to resist the strain of tension produced by their contraction in cooling.

If the heads of rivets have to be countersunk, their best shape is that of a truncated cone, the angle at the point of which cone would be of 75 deg.

The sectional area of the shaft of a rivet, expressed in square inches, is found by dividing the actual and total strain on the rivet, by the strain practically admissible on the square inch of the respective material.

We will now examine the riveting of simple round boilers. We designate by D the diameter of the boiler, by P the steam pressure per square inch, by t the distance between the rivets, by p the shearing strain on every rivet in the length-row. Thus the strain to which the boiler is exposed on every rivet-distance of its length, is expressed by $D \times t \times P$, and as this strain is divided on the two opposite sides of the boiler, we obtain the formula for the shearing strain on a rivet:

$$p = \frac{D \times t \times P}{2}.$$

The strain on a rivet-distance of the rows round the boiler, is measured by a triangle whose base would be the rivet-distance, and whose height the radius of the boiler. Consequently the strain on every rivet of the rows round the boiler is expressed by the formula—

$$p = \frac{D \times t \times P}{4}.$$

Now, to obtain an even distribution of the total pressure in the boiler over all its sections, the sectional area of a rivet has to be equal to the sectional area of the plate between two rivet-holes, and equal also to the double area of a section through the plate, from a rivet-hole to the edge. If we call a the thickness of the plate, d the diameter, and q the sectional area of a rivet, we obtain the formula—

$$q = (t - d) \,.a, \text{ or } t = \frac{9}{a} + d,$$

from which we conclude that the rivet-distance is dependent on the diameter of the rivets, and, reciprocally, the diameter on the distance. To determine these, it is necessary to take into consideration the possibility of making and keeping the boiler tight, which possibility depends principally on the relation between the thickness of the plate and the rivet-distance. Let us consider a special case to explain this more fully. We suppose a simple cylindrical boiler to have a diameter $D = 42$ in.; the thickness of the plate, $a = 0.3$ in.; the excess of the steam pressure over the atmospheric pressure, $P = 42$ lb. Under these conditions the strain of tension per square inch of plate-section, taken parallel to the axis of the boiler, is—

$$\frac{D}{2} \times P \times \frac{1}{a} = \frac{21 \times 42}{0.3} = 2{,}940 \text{ lb.}$$

In taking the areas of the rivet-sections equal to those of the plate-sections contained between two rivet-holes, according to the above rule, and in calculating the following items for three different rivet-diameters, for the sake of comparison, we find—

The rivet-diameter being . .	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.
Area of rivet-section (sq. in.), $q=$	0.307	0.442	0.601
Distance between rivets (inches), $t = \frac{q}{a} + d$ . . . . . . $=$	1.648	2.22	2.878
Shearing strain on a rivet (lbs.), $p = \frac{D \times t \times P}{2}$ . . . . . $=$	1,453	1,959	2,538
Strain per square inch on a section through the plate, or through the rivets in the length-rows of the boiler (lbs.) $= \frac{p}{q}$ . . $=$	4,730	4,430	4,220
[The shearing strain on rivets and the strain per square inch of section in the rivet-rows *round the boiler*, are one-half of those in the length-rows.]			
The strength of the riveting compared to the strength of the simple plate $= \frac{t - d}{t}$ . . . $=$	0.62	0.66	0.70

The advantages and disadvantages of the one or other of the chosen rivet-diameters are clearly shown by these tables. The $\frac{5}{8}$ inch rivets produce a very small comparative strength of the riveting (0.62). The $\frac{7}{8}$ inch riveting has a great comparative strength; but the distance between the rivets (2.878 in.) is too large in proportion to the thickness of the plate, to allow of a good and safe tightening of the joints. The $\frac{3}{4}$ inch rivets, not showing either of the two mentioned disadvantages in a considerable degree, are evidently the best in this special case.

S.

THE STEAM CARRIAGE SYSTEM.

From "Engineering."

So much has been said and, we may add, so much has been written, at various times during the past twenty years respecting the system of working railways by steam carriages, that the subject is apt to be regarded as somewhat a threadbare one. To a certain extent it may no doubt justly be so regarded; but, we think, to a certain extent only; and we believe that the steam carriage system is yet destined to receive far more attention from railway engineers than has hitherto been vouch-safed to it. And there are several reasons why this should be the case. In the first place there can be no doubt that, in the passenger-carrying stock of the present day, the amount of dead weight bears far too great a proportion to the paying load carried; and, secondly, railway proprietors have become cognizant of this fact, and not being rendered complacent by the receipt of enormous dividends are disposed to listen fairly to the arguments of those who advocate reasonable improvements in railway working. There are moreover, other reasons besides these—as we shall point out presently—why the steam carriage system is likely to receive a more extended trial than it has yet had.

The opponents of the steam carriage system state, as one of their strongest arguments against it, that it was tried twenty years ago and failed—or at least if it did not fail utterly, that it was abandoned because it was found that it did not satisfy the requirements of railway working. That the steam carriage system *was* tried and abandoned is undeniable ; but it is well worth while to inquire more closely into the reasons for its abandonment, and see whether they would apply in the present day. It is acknowledged even by the opponents of the system—or at all events by all those whose opinion is of any great value—that the running expenses of the steam carriages formerly tried were low, that the carriages did not lack adhesion or tractive power, and that they ran steadily at high speeds ; and it is therefore not to a want of these qualifications that we are to look as a reason for their disuse. Twenty years is a very long period in the history of railways, and very many important changes have taken place since Mr. William Bridges Adams's steam carriage "Fairfield" was set to work on a branch of the Bristol and Exeter Railway, and Mr. Samuel ran the "Enfield" on the Great Eastern—then the Eastern Counties,—line. At that time the average weights of locomotives and carriages were only about two-thirds what they are now, and the proportional reduction of dead weight effected by the steam carriage system was consequently far less than it would be at the present day. The early steam carriages, also, although reflecting great credit on their designers, had one very important practical defect, this being, that the engine proper and the part affording accommodation for passengers formed a single indivisible vehicle, and, as a necessary consequence, the carriage was exposed to the dirt and smoke generally to be found in an engine shed. The early steam carriages were also wanting in flexibility, as, although they were fitted with a contrivance of Mr. Adams's for allowing a certain amount of lateral motion to one of the axles, yet they were not adapted for traversing sharp curves, and their length was necessarily limited. In recent designs, such as that of Mr. Fairlie, lately illustrated in our pages, both these defects have been remedied ; such a system of construction being adopted that the passenger carrying portion may be readily detached from that furnishing the motive power, and may thus be housed separately, whilst the double bogie system gives perfect facility for traversing curves.

Again, the whole essence of steam carriage construction lies in effecting every possible saving of dead weight ; and there are now opportunities of effecting such saving which either did not exist or were not recognised twenty years ago. The use of steel, for instance, as a constructive material, has only become common, or, indeed, possible, during the last few years ; and our steam fire-engines and the launch engines made by our leading firms of marine engineers show its usefulness in light engine construction. It is in fact by the employment of steel for boilers, connecting and piston-rods, pistons, axles, tyres, frames, and other details, that the principal reduction in the weight of steam carriages is likely to be effected. The saving of weight in each detail may doubtless be small, but the aggregate of such savings becomes something considerable. Then, again, it is not so very long since such pressures as 140 lb. or even 160 lb. per square inch now carried in many locomotive boilers were unknown in railway practice ; and, as a necessary consequence, no advantage was taken in the earlier steam carriages of the reduction in weight of boilers and cylinders, which the adoption of such pressures renders possible.

So far we have only spoken of what we may term the constructive advantages likely to be possessed by the staem carriages of the present day over those of twenty years ago ; but we must now regard the question of their introduction from an entirely different point of view. At the time when steam carriages were experimented upon, our railway system, as a whole, differed materially from that which we possess now, and still more materially from that which we are likely to possess before many years have elapsed. Twenty years ago the construction of a railway was looked upon as an important work, nowadays railways may almost be said to be manufactured, and the opening of a new line, unless it be one of exceptional importance, receives little more attention than the completion of a new street or roadway. Twenty years ago, when the total mileage of the railways of the United Kingdom was only about one-third of the present amount, branch lines formed a comparatively unimportant part of the general system, and light surface lines, serving small country towns and villages, were unheard of. At the present time, on the contrary, we have branch lines innumerable, and the question of how best to work branch line traffic has become one of the most important problems with which railway men have to deal; whilst before many years have elapsed the necessities of the country will demand the addition to our present system of hundreds of miles of light railways following as closely as possible the surface of the country traversed by them, or in many instances constructed along roads already existing—railways which it will be impossible to work economically with the engines and carriages at present in use, and which will, therefore, have to have special passenger-carrying stock designed for them.

Now, it appears to us that in the numerous branch lines of the present day, and the probably still more numerous light surface lines and tramways of the future, there is an immense field for the employment of steam carriages, which had practically no existence when those carriages were tried twenty years ago; while even on our main lines there are, as we have on previous occasions pointed out in this journal, certain circumstances under their use which would be advantageous. We believe that the advantages of steam carriages would be more universally recognised if they were not so very generally regarded as something entirely distinct from ordinary rolling stock. A steam carriage is in reality nothing more nor less than a very light train and very light engine combined, and it should be regarded as a combination of this kind, and nothing else. But, it may be said, why not employ, in place of a steam carriage, a light carriage or carriages, of the ordinary form, drawn by an engine, also of the ordinary pattern, but of light construction? At first sight it may appear that such light rolling stock would possess all the advantages of steam carriages, and obviate some of their disadvantages; and, theoretically, this is, no doubt, the case. Practically, however, the construction of very light locomotives of the ordinary pattern involves many difficulties, and we do not hesitate to affirm that no independent locomotive, capable of drawing loads of, say, 30 tons or so over lines having moderate gradients, and capable also of being run steadily at speeds of 30 or 40 miles per hour, could be constructed with such a small amount of dead weight as an engine forming part of a well-designed steam carriage. With an independent locomotive, also, the weight available for adhesion is limited to that of the engine itself; with the steam carriage the adhesion weight can be increased by imposing upon the wheels a portion of the load drawn—an important difference.

Taking, then, all the bearings of the question into consideration, it appears to us, first, that steam carriages may now be constructed which will fulfill the requirements of the traffic for which they are intended far more perfectly than those formerly tried; and, secondly, that there is at present a vast field for the employment of such carriages, both here and abroad, which did not formerly exist. Such a steam carriage, for instance, as that of Mr. Fairlie,* would work the passenger traffic on any of the Welsh lines at what, we believe, would be found to be but a small portion of the cost involved under the system at present adopted. This being the case we are glad to find that a company has been formed—under the title of the Railway Working Association—to bring, amongst other matters, steam carriages fairly before the railway public. The company which consists of but a few members, includes several engineers well known for their experience in railway making and working, as well as other engineers of acknowledged standing in their profession; and it has purchased the whole of Mr. Fairlie's patents with a view to the introduction, both here and abroad, of rolling stock constructed on that gentleman's plans, and particularly of his steam-carriage system, of which we have lately had occasion to speak in very favorable terms. It is proposed by the company to, in the first instance, place these carriages on one or more of our English lines, and maintain them for a certain percentage of the receipts, so that their capabilities may be fairly and publicly tested. At first we believe that it is intended to employ the steam carriages for branch traffic, but subsequently the system may probably be extended. The company also propose to lease and work railways, and tramways, and let locomotives and rolling stock, and we do not doubt that they will find full scope for their operations.

New Method of Steam Generation.—Some notable results have lately been obtained by means of the circulation of a stream of mercury in a coil of pipe. The lower end of the coil receives the heat, while the upper end distributes it to the water.

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* See Van Nostrand's Magazine, No. 5, page 401.

THE MEASURE OF POWER AND FORCE.

Professor Henry F. Walling of La Fayette College, in referring to an article on this subject published in the "Chemical News."* asserts that the expressions MV and MV^2 are both proper, but independent measures of force; and discusses the subject as follows:—

We may avoid all confusion in this matter by adopting the modern expedient of giving different names to the same agent, in considering the different effects which it causes. If we define force to be that which, when associated with matter, causes it to move, the appropriate measure of quantity of force is "quantity of motion" or *momentum*, represented by *MV;* but when we consider the *work* which is performed, or to be performed, we find it convenient to use a unit of measurement entirely different in its nature from that of quantity of force or motion; and when measured by this unit, we term the acting cause "*power*" or "*energy*." The performance of work may be generally defined as the moving of bodies, or parts of bodies, through certain definite *spaces*, against continuous "resistances," or opposing forces. It may be represented in the form of an equation, thus—$P = ps$, proportional to MV^2, in which P represents the quantity of power or energy; p, the continuous pressure, or its equal, the resistance; and s, the distance passed through.

If any doubt should arise as to which measure is the proper one to make use of, we have only to ask ourselves what kind of effects are to be taken into consideration. In all the operations in which muscular power or motive power of any kind, acting through machinery, is concerned, *space effects* are what we have to do with—that is, we have to estimate the spaces through which matter is moved against opposing force; and ps, or its equivalent, MV^2, becomes the convenient and proper measure. On the other hand, when we consider the effect of a uniformly acting force like terrestrial gravity (within narrow limits), in giving motion to a body freely acted upon, we see that the force which becomes associated will be directly as the time—that is, equal increments of force will be added in equal times; and since we find that equal increments of velocity are also added, we have $F = ft$, proportional to MV: F representing the entire associated force; f, the force developed in a unit of time; and t, the time.

In applying these principles to any "question in mechanics"—that of the railway-train, for instance—it is only necessary to state the question clearly, and its answer is easily given. There are circumstances attending the motion of the train which tend to complicate the solution of the problem, namely, the resistance of the air, friction, etc. Frictional resistance is a consquence of motion imparted to molecules, by which their heat is augmented; the resistance of the air is simply due to its inertia, and thus a large part of the power of the locomotive is consumed in space effects upon the air, and the atoms or molecules of the rails, wheels, axles, etc. Having no exact means of determining the aggregate amount of these motions, we can only ascertain it by actual experiment.

We may, however, simplify the question by supposing the rails to have just sufficient inclination downwards in all parts of the train's progress to exactly balance the external resistances above mentioned. If, now, you would know the *moving force* required to give the train a certain velocity, it is clearly measured by MV, as shown in the previous editorial article; but if you wish to estimate the *work done* in giving it this velocity, or the work the moving train is capable of doing, if rendered independent of the locomotive, as the distance on a level, or up an inclined plane, it will move against a constant resistance, this quantity must be measured in units of its own kind—that is, of ps, proportional to MV^2.

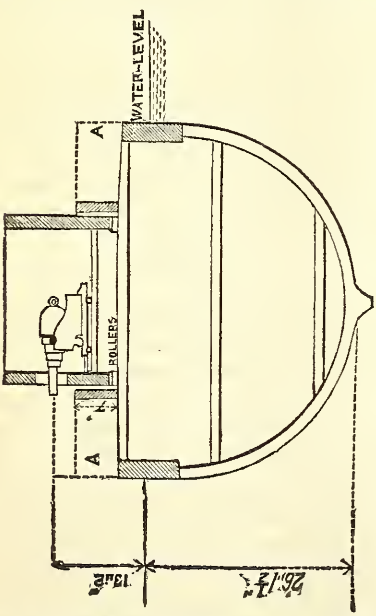
In estimating the amount of coal which must be consumed to perform a certain amount of work, we may suppose that the effect is due to the *falling together* of the atoms of carbon and oxygen, increasing the molecular motion or heat of the compound atoms of carbonic acid thus formed. This motion is transferred to the aqueous molecules, converting them into steam; the molecular motion of the steam imparts motion to the piston of the locomotive, and, finally, to the train itself. The sum of all the atomic weights, or rather attractions, multiplied by the distance through which the atoms have fallen, is the amount of work which they are capable of doing.—Hence the power thus generated is measured in units of ps, and is in direct proportion to the quantity of coal consumed.

We perceive, to sum up, that while MV

*See Van Nostrand's Magazine, No. 3, Page 275.

is the true measure of pure *force*, as an abstract quantity, *ps* or MV^2 is the proper measure for *power* to perform all mechanical operations.

THE NEW ENGLISH TURRET SHIPS.—The House of Commons has recently decided, by a majority of seventy-six votes, that England wants three new men-of-war; and that the best form which these men-of-war could assume was that of turret ships, each 4,400 tons burden, 285 ft. long, drawing 25 ft. 9 in. forward, and 26 ft. 6 in. aft, propelled by twin screw engines, nominally of 800 horse power, and carrying 1,750 tons of coal, assumed to be sufficient for ten days' consumption at twelve and a half knots—the maximum speed to be attained—eighteen days' consumption at ten knots, and twenty-five to thirty days' consumption "at a low rate of speed," a slightly indefinite parliamentary phrase. The ships are to have no masts, and will each carry two turrets, and two twenty-five ton guns mounted in each turret. The freeboard of these vessels is to be $4\frac{1}{2}$ ft. only. The bases of the turrets are to be protected by a heavily armored breastwork, 7 ft. high. The guns will be raised above the water 13 ft. 2 in., and will fire over the breastwork.



The cut, which we take from "The Engineer," is rather a sketch than a working drawing, but shows the general design. These vessels are criticized by some authorities, and approved by others. They will undoubtedly prove useful and efficient, especially in the steam engineering department, and their adoption shows the growing appreciation not only of the turret, but of the Ericsson system.

ON THE CENTRIFUGAL FORCE OF ROTATING SHAFTS.

By W. J. Macquorn Rankine, C.E., LL.D., F.R.S.

From "The Engineer."

1. *Object of this Communication.*—The object of this communication is to explain in a form suitable for practical application, the results of a mathematical investigation of the action of the centrifugal force in long lines of shafting; an action of which no similar investigation has, to my knowledge, been hitherto published; although it is one which may seriously affect the strength, durability, and economical working of machinery.

2. *Centrifugal whirling described generally.*—In Fig. 1, let A and B represent bearings at the two ends of a rotating shaft, and A B its axis of rotation. Any small deflection of the center line of the shaft from the axis A B gives rise on the one hand to centrifugal force, tending to make the deflection become greater, and on the other hand to an elastic stress, resisting the deflection, and tending to straighten the center line again. The resistance to deflection may be shortly called the *stiffness*. For very small deflections, the centrifugal force and the stiffness both increase according to the same law, being both sensibly proportional to the deflection simply; hence whichever of them is the greater for an indefinitely small deflection, continues to be the greater until some deflection is reached which causes a sufficient difference between their laws of variation. The consequence is, that if for an indefinitely small deflection the centrifugal force is equal to or greater than the stiffness, the shaft must go on permanently whirling round in a bent form, as shown by the curves A D B, A *d* B, to the injury of itself and of the adjoining machinery and framing: a kind of motion which may be called *centrifugal whirling*. On the other hand, if for an indefinitely small deflection the stiffness is greater than the centrifugal force, centrifugal whirling is impossible.

Fig. 2 represents by the curves E G, E g, the centrifugal whirling of an overhanging end of a shaft, the direction of whose axis of rotation E F is fixed by the bearing at E.

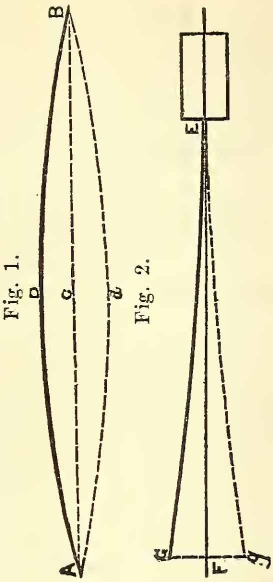


Fig. 1. Fig. 2.

For a shaft of a given length, diameter, and material, there is a limit of speed, and for a shaft of a given diameter and material, turning at a given speed, there is a limit of length, below which centrifugal whirling is impossible.

3. *General Nature of the Investigation.*—The mathematical expression of the conditions of the problem leads to a linear differential equation of the fourth order, integrable by means of circular and exponential functions. The integrals are (as might have been expected) identical in form with those obtained by Poisson in his investigation of the transverse vibrations of elastic rods (*Traité de Mécanique*," vol. ii., § 528); and some of the numerical results calculated by Poisson are applicable to the present problem. The relation between the limits of length and of speed depends on the way in which the shaft is supported. The only two cases which will here be given are those represented in Figs. 1 and 2, viz., the shaft supported on two bearings at its ends, and the overhanging shaft with one end fixed in direction. The general equations, however, enable the problem to be solved for an indefinite number of different ways of supporting the shaft.

4. *Formulæ.*—Let g denote gravity (= 32.2 ft., or 9.81 meters per second); H, the modulus of elasticity of the material, expressed in *units of height of itself* (say about 8,000,000 ft., or 2,400,000 meters for wrought iron); r, the square of the radius of gyration of the cross section of the shaft about its neutral axis $\left(=\frac{\text{diameter}}{4}\right.$ for a cylindrical shaft; $\frac{\text{diameter}}{\sqrt{12}}$ for a square shaft, etc.) and a, the angular velocity of rotation ($= 2\pi \times$ number of turns per second). Calculate a certain length, b, as follows:

$$b=\left(\frac{\mathrm{H}\, g\, r^2}{a^2}\right)^{\frac{1}{4}} \quad . \quad . \quad . \quad (1)$$

Then the limit of length, l, below which centrifugal whirling is impossible, bears a ratio to b, depending on the manner in which the shaft is supported, for example:

Shaft supported at the ends,

$$\left.\begin{aligned} l &= \pi b; \\ &= 3.1416\, b \end{aligned}\right\} \quad (2)$$

Shaft overhanging; direction of one end fixed,

$$\left.\begin{aligned} l &= 0.595\,\pi\, b \\ &= 1.87\, b \end{aligned}\right\} \quad (3)$$

In practical calculations it may be convenient to put instead of $\frac{g}{a^2}$, $\frac{\mathrm{A}}{n^2}$; where n is the number of revolutions per second, and $\mathrm{A}=\frac{g}{4\,\pi^2}$ (= 0.815 ft., or 0.248 meter, nearly) is the altitude of a revolving pendulum which makes one revolution in a second. This gives for the value of b,

$$b=\left(\frac{\mathrm{H\,A}\, r^2}{n^2}\right)^{\frac{1}{4}} \quad . \quad . \quad . \quad (4)$$

It is obvious that r should be expressed in the same units of measure with H and A; for example, in feet, if they are expressed in feet.

The inverse formulæ, for the limit of speed below which centrifugal whirling is impossible in a shaft of a given length, l, are of course as follows: Make $b = 0.3183l$ for a shaft supported at the two ends . . (5) or $b = 0.5347l$ for an overhanging shaft, (6) then the limit of speed, in revolutions per second is

$$n=\frac{r\sqrt{\mathrm{HA}}}{b^2} \quad . \quad . \quad . \quad . \quad (7)$$

The following are approximate values of H A, and its square root and fourth root, for British and French measures:

	HA	$\sqrt{\mathrm{HA}}$	$(\mathrm{HA})^{\frac{1}{4}}$
Feet, . .	6,520,000	25,500	160
Meters, .	595,000	7,700	88

5. *Shaft with additional Load.*—An additional mass turning along with the shaft, such as a pulley, has little effect on the centrifugal force when it is in the usual position—that is, close to or near to a bearing.

The effect of an additional rotating load distributed uniformly along the shaft may be allowed for by diminishing the height, H, of the modulus of elasticity in the same proportion in which the weight of the shaft itself is less than the gross load.

The effect of an additional rotating load at a point not near a bearing has not yet been investigated. The problem is capable of solution by means of the general integrals already known; but it is not of much practical importance ; for when a shaft is so long and so rapid in its rotation as to require precautions against centrifugal whirling, the first precaution is to avoid loading it with rotating masses which are not very near the bearings.

Glasgow University, *April* 2, 1869.

CONSERVATIVE ENGINEERING.

From "The Engineer."

Some twelve months since a pair of very handsome Corliss engines were put to work at Woolwich Arsenal. These engines have 26 in. cylinders or thereabouts, and are got up in a style which leaves nothing to be desired. They may be taken as types of the most advanced practice of the day and as such we speak of them here. From records carefully kept it appears that their average consumption of very good coal is a little over 3 lb. per indicated horse-power per hour. We think most employers of steam machinery will agree with us that this is a most excellent performance, very few stationary engines of moderate dimensions in our manufacturing districts burning less than 3.5 lb. or 4 lb. of coal per horse-power per hour. As far back as 1850 it was calculated that in the cotton factories of Lancashire the average consumption of coal was between 6 lb. and 7 lb. per indicated horse-power per hour, consequently, at first sight, the Woolwich Corliss engine, taken as a type, shows that very great improvements have been made in steam engines during the last twenty years or so. At the risk of astonishing our readers we venture to assert that the improvement exists more in imagination than in reality. In other words, steam engines are now, with certain exceptions, as regards the consumption of fuel, very much what they were in the day of James Watt, who was not quite such a fool as some modern engineers would have us believe. It would not be difficult to adduce hundreds of cases to prove our proposition ; one will perhaps suffice. Not long since we indicated a small factory engine constructed by Boulton and Watt, and started in 1811. Our diagrams showed that this engine was working to about one half more than its nominal power. Its consumption of indifferent slack was little more than $4\frac{1}{2}$ lb. per horse-power per hour. For repairs during the sixty years the engine has been at work, almost without intermission, it has cost little or nothing, and it is at this moment in excellent condition. Here, then, we have evidence, allowing for the difference between coal and slack, going to show that the most improved engines of the present day are really but 1 lb. of coal per horse-power per hour better than those built half a century since. As to durability, when a steam engine of what is now the modern type has lasted half a century and is still in good condition, we shall be happy, if still living, to admit that work done in 1869 was at least as good on the whole as that of our forefathers.

It is the custom with too many feeble-minded engineers to run down and depreciate the works of the mighty heads and hands that have gone before them. The custom is objectionable, and to be deprecated by every right-thinking man. We have quoted the case of the Corliss engine of 1868 *versus* the Watt engine of 1811 to show that, as regards factory engines, at all events, there is no foundation for the assumption that the modern engineer has beaten, and always can beat, his predecessors by an immense distance ; and nothing would be easier than to cite hundreds of other examples, selected from both the civil and mechanical branches of the profession, all demonstrating the great truth that the men who have passed away from among us, not only originated great inventions, but developed them, and gave them to us so far perfected that we find it no easy task to improve upon them. He must be a clever man who can beat James Watt, or George Stephenson, or Isambard Brunel on what they made especially their own ground ; and nothing is, we think, more unjustifiable than the assertion, but too often made, that these men and their work will not bear favorable comparison with the engineers of the present day, and the deeds of the last dozen years. We have no doubt whatever that the assertion is based on honest convictions—if any conviction can be regarded as honest, the reasons for which have not been thoroughly sifted by those who hold to them. But this fact has not sufficed to save many clever men from commercial shipwreck, or to elevate others from the great mass of snobs—Thackeray used the word, so we need not apologise for it—Radicals in mechanical science, the first held that all that had gone before their time must be susceptible of improvement; and disdaining to believe that engineers of sense and skill had ever lived till they were born, they launched out into extravagance, and, enamoured of change they adopted it for its own sake. For a time such men dazzle the world, and then they simply go out, and their place knows them no more. A little more conservatism of spirit, a little perception of the great truth that to change for the sake of changing is a mistake, a little more faith in the mental powers of the engineers who have passed away leaving their works behind them as everlasting testimonies to their skill, would have enabled many a modern engineer to win honor and gold, instead of that disappointment and penury which he has brought on himself by a reckless neglect of the teaching of the past.

Let it not be thought that this article is written without a special purpose, or that it is based on theoretical considerations. We write it with the special object of warning the rising generation of engineers against a fatal error which young men are but too willing to fall into. This error consists simply in holding that little or nothing is to be learned from the works of the last generation. Most young mechanical engineers determine that the moment they get a chance they will originate something great, or produce something in steam or general machinery which shall surprise the world. No greater blunder could be committed. If the young engineer has talents, he will find in the works of the past generation much to admire, something to avoid, and a great deal to imitate. If he lacks talent, his only chance of success is to adhere to the beaten track of precedent. In either case it is well to bear two facts in mind. The first is, that there is no more certain road to success than the power of utilising the experience of others; and the second, that innovating on established practice, is one thing, while making money is quite another.

We do not wish to be misunderstood. While advocating a conservative policy in engineering, we have no wish to stifle invention, or to bar progress by so much as a spider's thread. There is still enormous room for improvement in numberless departments of engineering, and we wish God speed to every one who endeavors to effect it. What we deprecate here is not the true spirit of improvement, but the false light, which, taking its rise in ignorance and vanity, leads men to commit great blunders, and to ensnare an innocent public in the net of destruction, yclept a limited company. Those who honestly determine that they will improve on what has already been done in any special branch of the profession, must begin by learning thoroughly what has been done, what remains to be done, and what those who have done part, have thought, and said, and written upon the subject as a whole. No true progress can be made in engineering science by him who treats the works of a past generation with contempt simply because they are old; and as years and experience come to men they will begin to perceive the truth of arguments which our younger readers may feel just a little disposed to pooh pooh. Facts crop up, indeed, every now and then in a curious and unexpected kind of way, as, for example, that which we cited in the first paragraph of this article, which should suffice to convince the most sceptical that at least sixty years ago engineers might be found in England quite as clever as any who have been born since; and the circumstance conveys a very important lesson, by which certain modern engineers would do well to profit.

CALCINATION OF IRON ORES.

From "Engineering."

Some months ago we drew attention to the ovens designed by Mr. Aitkin for this purpose, and gave a general description of their objects and construction.* Since that time we have received an account of the results obtained by the use of these ovens for roasting corbonaceous iron ores, such as blackband, and those results appear to justify very fully the opinion we formerly expressed as to the value of Mr. Aitkin's method.

The trials were commenced at the Almond Iron-works in Scotland early in 1868. Previously to that time the average make of the furnace had been from 515 tons to 720 tons per month, and the consumption of materials per ton of pig iron made had been on the average:

Coke.	Iron Ore.	Lime.
cwt.	cwt.	cwt.
$27\frac{1}{10}$	38	10

Actually the fuel used consisted of about one-third coke with two-thirds raw coal, and the corresponding proportion of coke has

* See "Engineering," vol. vi., pp. 501 and 552.

been calculated on the basis that 1 ton of coke equals 2 tons of raw coal.

Since the commencement of the trials this furnace has been worked with coked ironstone in the proportion of about 40 per cent., and about 60 per cent. of a mixture of one-sixth of a poor lean blackband, put in calcined, and of five-sixths clay iron ore, very difficult to reduce in the furnace, and sometimes containing as much as 20 per cent. of silica after calcination.

The coked ironstone has been analysed by Dr. Penny, who reports it to have the following composition, viz.:

	Per cent.		
Metallic iron	16.23	= iron	16.23
Protoxide of iron	36.29	= ,,	28.06
Peroxide	trace.		
Sulphide	2.09		1.33
Lime	1.07		
Magnesia	2.50		45.62
Phosphates, &c	3.63		
Silica and clay	8.00		
Fixed carbon	27.20		
Water	2.60		
	99.61		

By the analysis of Staffordshire blackband similarly treated, the amount of iron in the metallic state was 36.48; that of protoxide, 33.66 per cent. The slag obtained in working the furnace with calcined ore was found to be very free from metallic iron.

During the eleven months that calcined ore has been used, the make of the furnace has been on the average, 600 tons per month, ranging from 567 to 741 tons. The consumption of coke per ton of pig iron made has varied from 1 ton 8 cwt., when only 8 per cent. of the coked ironstone was used, to $17\frac{1}{2}$ cwt. when the proportion used amounted to $42\frac{1}{2}$ per cent. Throughout this period the proportion of the coked ironstone was gradually increased from $8\frac{1}{2}$ per cent. to $42\frac{1}{2}$ per cent., and the tabulated quantities of fuel consumed, show that the saving of fuel was proportionate to the amount of calcined ore in the working charge. With the largest proportion of the coked ironstone, this saving amounted to 35 per cent., or $9\frac{1}{2}$ cwt. of coke per ton of pig iron made, for in the place of the former average consumption with raw ironstone of 27 cwt. per ton of pig iron, the consumption with coked ironstone was only $17\frac{1}{2}$ cwt. per ton of pig iron. This fact considered, together with the refractory nature of the clay ironstone amounting to more than one-half the burden, would seem to afford conclusive evidence that a very great advantage is to be gained by calcining the iron ores of a carbonaceous nature according to Mr. Aitkin's method, and that there would be a great probability of effecting a still more considerable saving of fuel in the smelting of the ore if the whole burden of the furnace were coked black-band.

The Shotts Iron Company have lately commenced working with coked ironstone. Formerly the burden of the furnace consisted of $14\frac{1}{2}$ cwt. coal and $14\frac{1}{2}$ cwt. calcined ironstone, and since using the coked ore it has been only $3\frac{3}{4}$ cwt. of coal to $14\frac{1}{2}$ cwt of ironstone.

The amount of fixed carbon in the coked blackband above referred to is equivalent to about $5\frac{1}{2}$ cwt. of coke per ton of the ore, and since that would be to a great extent burnt away by calcining the ore in open heaps, it must be regarded as so much fuel saved. Besides this, the calcination in close ovens admits of the volatilisable portion of the bituminous contents of the ore being turned to account either as fuel or otherwise. This is a further source of saving; besides this, it must be remembered that by calcining in close ovens the oxidising influence of atmospheric air is excluded, and consequently the work of reducing the ore may be in part performed in the calcining kiln, leaving so much the less to be done in the blast furnace, as is shown by the amount of metallic iron in the coked ironstones referred to above.

Any one who has seen blackband ironstone calcined in the open air calcining heaps must have been struck by the enormous amount of combustible material that is being simply got rid of in that operation, and by reference to the analyses of this ore it will be evident that the carbonaceous portion which has hitherto been almost entirely wasted, may amount to as much as three-fourths of the fuel subsequently used in the blast furnace for reducing and melting the ore. Mr. Turran* has estimated the possible saving to be effected by substituting kilns for open air calcination, as amounting in the case of Scotch blackband to as much as 10s. per ton of pig iron, and his experience at the Dowlais Works of calcination in kilns as compared with open air calcination, is decidedly in favor of the former plan, for even after allowing for the interest of outlay for kilns, the cost of labor and fuel is much less with open air heaps.

* The Iron Manufacture of Great Britain, p. 15.

Such a mode of effecting economy of fuel in a business where the gross quantity of fuel consumed is so enormous should receive the earnest attention of those concerned, and there is probably no case in which such economy and reduction of working expenses is more necessary than in iron smelting. We therefore hope Mr. Aitkin's plan of calcination may be taken up by ironmasters actively, and that we may soon be in a position to report its extensive adoption.

REVOLVING SODA FURNACE.

Translated from "Annales du Génie Civil."

M. Lamy, professor of Chemistry at the Central School of Arts and Manufactures, made, at a recent session, a communication on the subject of "revolving furnaces," as used in England for the manufacture of soda. The material so designated is the carbonate of soda, which, according to its various forms, is called "crude soda," "sal soda," or "crystalized soda." It is an article of prime necessity, being indispensable in the manufacture of glass, soda, bleaching material, and in numberless other arts. Its production is an important branch of French industry. An important accessory result is the increase in the manufacture of sulphuric acid, which is largely used in the process.

The production of artificial soda, by the way, is altogether an art of French origin, being invented by Leblanc, whose name and deeds are too little remembered in France. It is remarkable that the process employed, the apparatus, and even the proportions of the mixture, are the same as those used by the inventor, notwithstanding all the research which has been made during three quarters of a century with the design of improving them.

M. Lamy describes the manufacture by the use of sulphate of soda, chalk and charcoal, heated to a pasty fusion in a reverberatory furnace called a soda furnace. The reaction takes place at a high temperature by means of vigorous stirring, which requires the work of skilled laborers, strong and intelligent, and receiving therefore, liberal wages. Crude soda is thus produced, from which, by lixiviation and crystalization, is extracted the 30 to 35 per cent. of carbonate contained.

The French manufactories produce annually about 100,000 tons of the various salts of soda, and in England, where the production is largest, it amounts to 300,000 tons. The high price of the requisite labor has led to a vigorous search for some substitute for manual labor. Two systems have been proposed; the first, that of Mr. Pattinson, effects the mixture by means of iron agitators attached to a spindle, fixed in the center of the furnace, and receiving its motion from a steam engine. This system was speedily abandoned. A more successful attempt is the revolving furnace of Messrs. Elliot & Russell, perfected by Messrs. Stevenson & Williams, at the chemical works at South Shields near Newcastle. It consists of a large cast iron cylinder about 5 meters long (horizontally) and 3 meters diameter, lined in the interior with refractory bricks. Its interior space is not cylindrical, but is enlarged in the middle, in order to keep the materials in the center—shaped in fact like a cask. It has also, in the interior, two longitudinal ribs, situated diametrically opposite each other, in order to effect more thoroughly the mixture during the revolution. The cylinder rests upon four friction wheels, which are supported upon a massive frame. On the exterior circumference are teeth, gearing with a pinion driven by the engine at any desirable speed. The charging hole is in the middle of the circumference, and closed by a cast iron gate. The openings at the ends serve, one for the introduction of fire from an adjoining furnace, the other, for the escape of the products of combustion, which are carried off into various accessories, and utilized in the solutions, evaporation and lixiviation. The communication of fire to the cylinder is made by means of a movable flue, held by a chain, and lined with fire brick, without which, small and unforeseen derangements might cause accidents. A great amount of fire is indispensable to a sufficiently energetic action throughout the whole of the furnace. To "cook" a charge of soda, the cylinder is raised to a red heat, and turned into such a position that the charging hole corresponds to a chute, in towhich the barrows dump the materials for the charge, which consists of 1,300 kilog, of carbonate of lime, 500 kilog of coal, broken up quite small. The cylinder is then given ten revolutions per hour, or a turn in six minutes. After an hour and a quarter the lime is calcined, and there is then added to the charge 1,160 kilog of sulphate of soda, with 180 kilog of coal, and the cylinder is revolved at the same rate half an hour longer. At the end of that time the reaction commences with the fusion of the materials, and the velocity is increased to two turns per minute. The operation terminates in about half an hour at this rate of rotation. The cylinder is stopped with the charging hole at the lowest point, and the semi-fluid soda is drawn off into vessels moving upon tram-ways underneath.

This operation lasts two hours and a quarter, and admits of six heats and a total production of 18,000 kilog of crude soda in 24 hours, which is three times the product of an ordinary good English furnace. The heat is distributed in the most uniform manner, the sulphate is more perfectly decomposed, the operation more completely protected from the access of air, the manual labor greatly diminished, and the consumption of coal reduced in the ratio of 362 kilog to 544 or about one third. It was found at the outset that the plant was very expensive and subject to frequent disarrangement. Lately, however, the patents have expired, and the details of the furnace have been perfected so that it works with all desirable regularity, and costs, in England, not more than 35,000 francs. Mr. Stevenson has mounted four of these furnaces in his establishments, and a dozen others are working elsewhere in England—notably at Widness and St. Helens. They are built by Mr. Robert Daglish at the St. Helens foundry in Lancashire.

PULLEYS WITH LEATHER COVERING.

Translated from "Polyt Centralblatt."

The sliding or slipping of belts on the pulleys is an evil experienced by almost every one whose business depends on machine power. Various means have been devised to avoid it. One of them is to strew powdered rosin or pitch on the inside of the belt. Another is to cover the pulleys with wood. A third is to give the rim of the pulley a curved surface. These means are only palliatives, and lack a thorough, steady and continued action. Rosin and pitch are soon pressed into the leather, when they not only lose their efficacy, but contribute to the rotting and destruction of the belts. A wood covering on the pulley gets polished in a short time and is then as slippery as iron. It is therefore necessary to frequently roughen its surface, by which operation the diameter of the pulley is diminished and the proportions of the transmission are altered. A convexity of the rim of the pulley is very effective to prevent the dropping off of the belt, especially when the pulley has a horizontal position; but it counteracts the slipping of the belt to but a small extent.

We therefor take pleasure in communicating to the public a mechanical contrivance, which completely prevents the sliding of belts and all the great disadvantages resulting from it. It consists in covering with leather the working-surface of the pulleys. As the friction of leather on leather is equal to five times that of leather on iron, and as leather can be roughened and be easily kept in that condition, it is evident that a sliding of the belts cannot take place on pulleys covered with leather, not even then when the belts have to transmit the very highest amount of power. We have seen such pulleys working in sugar factories, breweries, in manufactories of German silver, in paper mills, machine shops, sawing mills and in many other mechanical establishments, in all of which they have proved of eminent usefulness and great practical value. With pulleys which have to run with a great velocity, as, for instance those that have to drive blowers and saw-frames, as well as with pulleys of small diameter, which have to transmit powerful strains, the advantages of a leather covering are especially great. But besides these evident advantages that result from the avoidance of the slipping, a leather-covering on the pulley preserves the belt; in the first place because the belt does not require tightening so hard, the friction being considerably increased; and in the second place because there is no occasion for a rapid rotting of the belt. For this rapid rotting is generally caused by the fact, that under the influence of the heat produced by friction the tannic and sebacic acids contained in the leather of the belts, combine chemically with some of the iron of the pulleys, forming a hard compound in the belts, which produces what is called rottenness and frequently causes breakages. This evil is of course avoided by covering the pulleys with leather. These covered pulleys are manufactured by Mr. S. Freund, Jr., 8 Neuenburger Strasse, Berlin, (Prussia). The coverings are fixed to the pulleys by a kind of paste or glue, which hardens in a very short time and sticks so well to iron and leather, that the greatest forces can be transmitted by the pulleys without loosening the leather. The operation of covering is very simple and can be done and renewed by every intelligent workman. The mentioned factory is prepared to send coverings and glue abroad, together with full and explicit directions showing the way to put them on. The price is $1\frac{5}{6}$ Prussian thalers per square foot of leather, including the glue. (Berggeist.) S.

MERCHANT MARINE.

ADVANTAGES OF IRON SAILING VESSELS.

Translated from the "Revue Maritime et Coloniale."

It seems tolerably certain that iron sailing vessels are to play an important part in the future of the merchant marine. They are more substantial, more durable, and of greater carrying capacity, than wooden vessels of the same displacement. They attain also as great speed, or even greater, for they may be constructed of greater length, and their capacity increased, while maintaining the same spread of canvass, and consequently the same equipage. The length may be six times the beam, in an iron vessel, without interfering with facility of manœuvering. The damages to a metallic hull may be repaired, at least provisionally, in almost any part without interfering with its serviceability, or capacity of continuing its voyage. At sea, iron ships behave as well as wooden ones, and resist better the stress of storms.

For East India navigation, iron hulls are free from all fears of rot, which at the end of six or seven years, and sometimes earlier, attacks wooden vessels engaged in carrying fermentable cargoes, such as rice, sesame, etc. Moreover, French vessels which frequent Indian seas, being generally of small or moderate tonnage, often find it advantageous to obtain local employment there, when a return to Europe holds out no hope of profit. But it often happens that wooden vessels cannot avail themselves of these opportunties, either through fear of having to go into dock in a foreign country, or to make repairs at some far-off port, which are enormously expensive. With iron vessels these inconveniences are avoided.

At Calcutta there are always about forty or fifty iron vessels, of about 50,000 tons altogether, which always obtain preference to wooden vessels, and generally at a higher price. It is well understood by shippers at that port, that iron vessels generally deliver their cargoes in a more satisfactory condition than wooden ones. Masts and lower yards of iron and iron top-sail yards have also great advantages, both in respect of durability and staunchness. Some English vessels have also the top-masts and standing jib-booms of iron. Iron wire rigging is generally adopted in vessels making long voyages. A suitable application of paint to protect the bottom is indispensable for the preservation of plates and rivets. Great care is necessary in taking such a vessel into dock, since it will not take paint properly until it has been scraped, scoured, washed, and perfectly dried. After a passage of one hundred days from Cardiff to Calcutta, the writer's vessel had not diminished her speed at the end of the voyage.

It is desirable that the French *Veritas* adopt for iron vessels the system of classification of the English Lloyds.

Sanitary Treatment of the Refuse of Towns and the Utilization of Sewage.—Mr. Menzies lately read a paper on this subject before the Institute of Surveyors. The paper, besides dealing generally with the subject, was devoted to an exposition of the "separate system" of drainage of which Mr. Menzies is the originator. That system is, that the rainfall shall in all cases, as a principle, be entirely separated from the sewage; the rainfall being conveyed to the nearest outlet, and the sewage to the most appropriate land for utilization. The advantages claimed for the idea are many. The first anticipated is, that there will be no gullies or openings into the streets communicating with the foul drains by which effluvium can rise into the streets or courtyards; the second, that men will not require to enter into the drains to clean out the sand and grit from the roads; the third, that no over-flows of foul or sewage matter will be necessary; and the fourth and most important, that the treatment at the outlet by irrigation will be uniform, economical, and practically perfect. The fifth advantage is, that perfect and continuous removal of all sewage may be secured by a complete system of flushing, under command at all times and at all seasons; and it is worth observing that the greatest flushing will be necessary, or rather desirable, in the town in dry weather, just when the fields outside will take it best. The sixth advantage is, that when pumping is necessary, as it is in such a vast number of cases, the economy will be very great. The idea was first brought before the public by Mr. Menzies in 1865.

THE BESSEMER FLAME.

From a paper read before the Philosphical Society of Glasgow, by Thomas Rowan, F.C.S., F.R.S.S.A., Atlas Works, Glasgow.

The Bessemer process for the manufacture of steel is now among the most important of our metallurgical operations, the chemical changes being as interesting as the mechanical appliances designed for the working of the process are ingenious. On account of its comparatively recent introduction among established industries, it affords an ample field for scientific investigation; and there is no feature of the process at once so interesting and important as that of the flame which issues from the "converting vessel."

The success of a "blow" undoubtedly depends on the accuracy and completeness of many details, but, of them all, the most important is to know and catch that moment in the existence of the flame, when the carbon in the iron has yielded its last trace to the oxygen of the air.

If a charge is "overblown," that is if it be subjected to the action of the air for too long a period, or if it be "under-blown," that is if the admission of air is stopped before the proper chemical action has been completed, the steel will be found to be defective in proportion to its unskilful treatment.

The flame issuing from the converter is the index of these changes which the molten mass of metal is undergoing during the process; but the exact moment of decarburisation is often, from a variety of causes, difficult to determine.

It is for these reasans that the examination of the flame forms the point of attraction of the process, and I have thought it might not be uninteresting to describe the general appearance which this flame presents to the eye, and some experiments which my brother has made with the spectroscope, and with colored glasses, for the purpose of more readily determining that critical period or "change" in the flame which I have spoken of. The success of these latter experiments has enabled him to attain the object for which they were commenced, and he has designed an instrument, which I shall describe hereafter, by which the "change" in the flame is more easily determined.

1. THE GENERAL APPEARANCE OF THE FLAME TO THE EYE.

When the vessel is first turned up a shower of brilliant sparks is ejected owing to the force of the blast reaching first a thin layer of metal as the vessel slowly swings round to the vertical position.

From 0° to 3 or 4 minutes.

When the full head of metal is over the blast, at first for three or four minutes, there is scarcely any flame, only a current of very hot gases and very numerous sparks.

From 3 or 4 to 5 or 6 minutes.

Gradually a small pointed flame appears in the centre of the sparks, and this quickly increases in size without gaining much brilliancy for two or three minutes.

From 5 or 6 to 9 or 10 minutes.

During the next period of 4 or 5 minutes the flame is very unsteady, both in size and in position, and its oscillations are accompanied by hollow sounds as of reports or explosions in the interior of the converter.

From 9 or 10 to 11 or 12 minutes.

Streaks or flashes of brighter flame now shoot up through this comparatively non-luminous flame, and within 1 or 2 minutes give place to a continuous stream of dense and brilliant fire which rushes far up the chimney and illuminates the entire building, often casting the shadows of the cranes, etc., against the windows through which the sun is shining.

From 11 or 12 to 15 or 16 minutes.

This flame gradually becomes thinner and more transparent without losing any of its brilliancy during the 6 or 7 minutes of the "blow," which generally remains, until it suddenly (preceded, however, by a few hollow and peculiar sounds from the interior of the vessel), loses its brilliancy and much of its size, and drops down within about half a minute to about the size it had reached at about 5 minutes of the blow, this flame, however, being both more dense and more luminous than the flame at that earlier period.

Any of the stages described may, from a variety of causes, be prolonged; or an insufficiency of blast, howsoever caused, may lengthen the entire period of the "blow" for several minutes, but the above is a fair average "blow" with the best English hematite pig iron. If inferior irons are used the flame at the change is more or less enveloped in a dense white smoke, and the change is accompanied by violent pulsations or "coughing" of the entire flame, which, under these circumstances, has often a yellowish red color to the eye, all this making the change often very difficult, if not impossible, to detect.

Nervousness or biliousness, by variously affecting the sight of the observer, may also render him unable, *with certainty*, to determine the precise moment when he ought to "turn down," and there is a marked difference in the facility of observation noticeable between a blow taking place in daylight and one at night.

2. THE APPEARANCE OF THE FLAME.

It was important, first, to note if any of the lines belonging to the Bessemer flame were to be found in the flame given off from the coke fire used to heat up the "converter." Several examinations were made; the result of these was that, besides the invariable yellow bright line, the red line and the two bright green lines next the yellow were occasionally to be seen. Owing, however, to the want of brilliancy of this flame, the spectrum which it gave was very faint, and at times almost invisible.

On first turning up the vessel, and for about four minutes thereafter, the spectroscope showed only a continuous band of light, with the colors rather hazy, and so much blended with one another as to make it impossible to mark the junction of the different fields.

In from four to six minutes flashes of the yellow line became visible (corresponding to the appearance of tongues of a bright flame shooting up in the centre of the dull red one issuing from the mouth of the "converter"), and in one or two minutes after its first appearance, this line became quite steady, and did not disappear even at the end of the "blow." Simultaneous with the steadying of the yellow line, the red, yellow, and green fields became clear and well-defined bands of bright color.

In half to a minute later a bright green line appeared near the yellow, following which, in scarcely ever more than half a minute, a red line appeared equidistant from the yellow (of course on the opposite side). These two generally became steady together (having first appeared in intermittent flashes) in about half a minute after both were visible. With the steadying of these two lines, at once a second green line (bright and about the centre of the green field) became visible, wavering a little at first. About a quarter of a minute served generally to steady it, although sometimes it was a minute and a half from the appearance of the first green line till the second green line with the red became steady. In one to two minutes a third green line nearer the blue field came into view, and in about one minute was steady.

When the red appeared with the first green line, the second and third green lines generally appeared together, but when the red appeared with the second green line, the third green was accompanied by a blue bright line near the green field. In about ten minutes after turning up the converter the flame attained its maximum size and intensity of light; when a second and third bright line became visible in the blue field; very often these were only intermittent and very faint, but with "hot metal" and a bright flame they were pretty steady and distinct and were broader than those in the yellow, green, and red fields.

Occasionally, for about two or three minutes before the close of the blow, a bright line was seen in the purple field, pretty far to the right of the spectrum. Sometimes this only flashed brightly, but on a few occasions it was clearly seen, though faint.

With a very bright flame several dark lines were seen, but for want of definiteness it was impossible to say whether they were not due to the contrast afforded by the brilliancy of the bright ones besides which they appear. A narrow, dark line was seen on each side of the red line, and a broad, dark band dividing the yellow from the green; then one between each green line, and two in the blue field between the three blue lines. But these were only seen with an exceptionally bright flame, and therefore are not of much importance.

All the bright lines visible remained steady for several minutes before the close of the blow, affording an excellent opportunity for their examination; but at the last all, with the exception of the yellow, faded in less than thirty seconds. The purple line disappeared first, whenever it happened to be visible, then the three blue lines in the inverted order of their appearance, then the third green, after which the second, then the red, and last of all the first green, when the blast was shut off.

The green and the red lines, from their distinctness, afforded the best point for a determination of the process; and these were so constant that a sure indication could always be given by any of them, if it were made the index by which to determine the period of blowing.

Very often, on adding the charge of spiegeleisen, a large and very brillant flame rushed out of the "converter" for some minutes; and on examining it the red, yellow, three green, and a very brillant purple line were seen, but no blue line.

3. SOME EXPERIMENTS WITH COLORED GLASSES ON THE FLAME.

I shall now proceed to describe some experiments made with colored glasses on the Bessemer flame. I may mention that what led to them was my brother being compelled to get very dark spectacles to protect his eyes, which were not very strong, from the intensity of the light of the flame. The first pair made completely overcame the brilliancy of the flame without imparting any color to it; but on ordering a second pair they showed so much color as to render them useless. On appealing to the workman who had made them, he found that no note had been kept of the kinds of glasses which had been used in the first pair; and although several attempts were made to repeat them, the second pair sent was the best he could accomplish, and they had appeared colorless to sun light. The thought then occurred that as the brilliancy of the flame varies considerably during its existence, a variation in the *amount* of transmitted light might be found to affect in a proportionate degree the power of some colored glasses to absorb colors in combination with them, and that a combination of colors might be found to give, with a small quantity of transmitted light, a distinct color which could be quite absorbed when a large quantity of light was passed through the same glasses.

Another, and perhaps the most important, consideration which led to the following experiments was, that the flame itself has a varying chemical composition as the silicon, manganese, carbon, and iron becomes successively attacked, and that the *temperature* of the flame at these various stages must necessarily be altered, giving rise of course to various colors or shades of color in the flame. If therefore a combination of colored glasses could be found which would absorb the color due to the flame at a particular temperature, it seemed clear that a *change* of temperature would become immediately visible on account of an accession or diminution of color to the flame as thus observed.

It is probable, too, that some of the color possessed by the flame at its different stages is due to the various elements which are at these periods being volatilised, but the spectroscope does not throw much light on this supposition.

The first combination of colored glasses which I have noted are a ruby and emerald. It was found that these colors mentally destroyed each other.

The Bessemer flame when viewed through them appeared white, and without brilliancy.

Ultramarine blue, dark yellow. This combination gave the same effect as above.

With a combination consisting of ultramarine blue, dark yellow, ultramarine blue, and emerald, the flame appeared of an emerald color, but was dark and without brilliancy.

In the next experiments the dark yellow and one blue were replaced by a light yellow and neutral tint thus; Ultramarine blue, light yellow, nentral tint, emerald. The appearance of the flame in this case was similar in color to that afforded by the above combination, but appeared of considerable brightness.

In the next experiments the light yellow and neutral tint were replaced by a dark yellow and red respectively, thus: Ultramarine blue, dark yellow, ruby, emerald. The flame at first was dimly seen, and without color. When it reached its maximum brilliancy it still appeared white through this combination.

With these five combinations the appearance of the sun as seen through each of them was similar in character to that of the flame, but more powerful in degree.

In the subsequent experiments the combination was as follows: Ultramarine blue, dark yellow, neutral tint, ultramarine blue. The flame appeared at first of a ruby red color, increasing in size and intensity as the "blow" progressed, the edges of the flame acquiring a lighter shade of red; but the color was too strong to admit of the changes being easily determined. Sunlight, through this combination, was slightly yellow.

In the succeeding experiments one of the blue glasses was replaced by a light yellow, giving a combination of ultramarine blue, dark yellow, neutral tint, and light yellow. The flame appeared at first of a yellowish red color. As the "blow" progressed this color became whiter with flashes of redder flame occasionally through it. At the flame's maximum brilliancy the edges assumed a light red color (nearly white), while at the root and center of the flame the color was of a darker yellowish red. When the flame dropped (at the end of the "blow") it returned to a yellowish red color, somewhat similar in appearance to the effect produced at the beginning of the blow.

Sunlight appeared slightly yellow. It will be observed that this combination gave nearly the desired effect, viz, a variation of depth of color due to the differences of temperature or brilliancy of the flame at its different stages of progression.

The yellowish tint, however, always present, showed a defect in this combination, to overcome which, further trials were made. Among other devices the light yellow was omitted, and the flame was observed with ultramarine blue, dark yellow, neutral tint. The flame appeared still red, and with the yellowish tint, though in such small degree as to show that the desired result was not far off.

Sunlight appeared dim and slightly yellow.

In the concluding experiments the neutral tint was replaced by a blue glass, with the object of ascertaining whether the yellow color could be arrested by the omission of the red or the blue component of the neutral tint, thus: Ultramarine blue, dark yellow, ultramarine blue. The combination was perfectly successful, the lingering trace of yellow being removed.

I shall now describe more fully the general appearance of the flame through it.

For the first four or five minutes all is dark, the chimney is invisible; nothing but the mouth of the converter can be made out, which appears slightly red, the sparks coming from it being scarcely visible. As the blow progress the red color increases in size and luminosity, while the outline of the vessel becomes visible.

In about twelve to fifteen minutes the flame begins to lose its color, becoming violently agitated, flashes of a lighter and brighter flame shooting up occasionally.

In about fifteen minutes a purple tint becomes visible round the mouth of the vessel, the flame gradually acquiring a white color towards the edges.

When the flame has reached its maximum brilliancy, it appears bright and nearly white, with the edges purple. The red color thereafter begins to re-appear at the mouth of the vessel and centre of white flame, gradually extending until the whole flame appears of a light red color, and with the peculiar hollow sound heard in the vessel always preceding the drop.

The centre of the flame begins to acquire a deeper color; this quickly extends and deepens. Within a minute or so of the drop, the whole flame becomes crimson, and losing its brilliancy, and within half a minute it suddenly goes back to very nearly the red color it had at starting.

This combination of glasses is now in daily use in the Atlas Works, its indications being so marked and unmistakable as to render its use safe in the most inexperienced hands. This little instrument, or "chromopyrometer" as it is purposed to call it, is arranged as follows:

One of the blue glasses and the dark yellow one are fixed in a rectangular frame, carrying at its foot a hinge, to which the thin frame holding the other blue glass is attached, and at its top a spring catch to hold this smaller frame when in its shut position; and also a pin and set screw for attaching the whole instrument to the hat of the observer, so as to place it before his eyes.

The object of having the glasses thus divided is to give facility for the observation of the flame through the combination of three, while, during the pouring, two being sufficient, the third one is allowed to hang down, when it serves to protect the lips from the great heat of the ladle and liquid steel.

In conclusion, I think it is probable that by carefully noting by means of colored glasses, such as that described, the amount of light (as determined by the shade of color visible) emitted by flames of known temperature, a scale might be formed which would enable us approximately to measure the temperature, not only of the flame of the Bessemer converter, but also that of many flames which have hitherto been considered beyond the reach of our ordinary methods of measurement.

THE MANUFACTURE OF SULPHURIC ACID.

HISTORICAL NOTICE.

Translated from "Le Génie Industriel."

Thirty years ago the only available source of sulphur, for the manufacture of Sulphuric Acid, was the volcanic region, or sol fataras of Sicily. Our national industry was, therefore, in a measure, dependent upon the complaisance of foreign powers, and at the mercy of political and commercial vicissitudes. It was probably this state of affairs that prepared the way for the development of some source of this precious mineral in France. The same stimulus was felt in other countries, and gave rise, no doubt, to the strenuous efforts made to discover within their own soil the means of release from this burdensome dependence. At length, after much research and experiment, the industral world became indebted to a Frenchman, Michel Perret, for the first success in the new path;—a name, unfortunately, too seldom remembered. The first success in obtaining sulphur from pyrites, in the form of sulphurous acid, was attained at Lyons, near which city large deposits are found. This innovation gave to the manufacture of sulphuric acid, and through it to the chemical arts generally, such an impulse that the consumption has increased tenfold within the last thirty years.

Prior to 1833 there was a prevailing impression, derived from numerous unsuccessful experiments, that the sulphurous gases derived from the burning of pyrites, were unsuitable to the production of sulphuric acid. It was generally believed that pyrites would not burn without fuel, and it was therefore roasted with a mixture of coal. The distinguished chemist, Climent Dèsormes, had proceeded in this assumption, in using cupola furnaces, in which he was able to utilize only a small part of the gases so obtained. At that time M. Michel Perret proved that sulphurous acid gas, disengaged by the combustion of pyrites, was essentially well adapted for conversion into sulphuric acid. With this view he constructed in his father's workshop some muffle furnaces, in which he burned the pyrites, without mixing the products of combustion with those of coal, the proportion of air necessary to carry on the condensation in the chambers being very carefully regulated. This surmounted the difficulty satisfactorily. The date of the first patent for fifteen years was February 2d, 1836, and it was taken out in the name of his father, who had encouraged him in his labor and studies. The young man, at that time but twenty years of age, showed himself on more than one occasion to be a profound thinker and fertile in new ideas. The success obtained by the application of this process, for several years, on a scale of some magnitude, led to further investigation into means of economizing the combustion. The use of the old furnaces was revived, but without the use of coal. M. Baptiste Perret and M. Olivier, brother and brother-in-law of the inventor, united with him in the work of improving the process, which by their united efforts has reached the stage in which it may now be seen in the factory of St. Fons, near Lyons—one of the principal establishments of the Perret firm. We may mention one of the improvements due to M. Michel Perret, viz: the apparatus for utilizing those portions of the pyrites which are reduced in the crushing process to a state of fine division, constituting a considerable portion of the whole, and which would otherwise be wasted. A small model of the furnace used, arranged so as to show a section through its axis, and giving a complete idea of its construction, is exhibited in the window of the Perret firm, and the use of the process is freely open to all who are engaged in this branch of industry. At a little distance from a layer of pyrites in lumps, burning in an ordinary box furnace, is placed a sole of large refractory bricks, six centimeters in thickness, such as are used for spreading out plate glass. Imagine now seven other similar soles, separated by intervals of six centimeters, in a mass of masonry in which the openings are so disposed that the current of air, coming from the roasted lumps, will envelop in a very circuitous manner the surface of the pyrites in the form of powder or small pellets, spread out upon each sole. Each layer of pyrites, heated by the combustion of the preceding one, burns, either by the direct admission of air into the mass, or by a kind of cementation, requiring thirty-six hours for its completion, to such a stage, that not more than four or five per cent of sulphur remains uncombined. As might be expected, the temperature increases as we approach the upper end of the series. Mr. Michel Perret thought that the number of soles might be increased beyond eight, and he therefore constructed a furnace in which the number was carried to sixteen. But as their superposition gave a great altitude to the furnace, he divided it into two series, parallel with each other, in such a manner that the gas from the eighth and upper sole was carried by a recurved flue over the surface of the lower layer in the second series. In this furnace the temperature steadily increases from the sole where the lumps are ignited to the uppermost layer, showing with what facility the air penetrates the mixture of powder and grains of pyrites, which is spread out to a depth of three centimeters in each layer. It would seem, in order that the air may circulate in the intended manner, that all possible means of access, excepting those provided, should be rigidly closed. This can be readily managed, so far as the back part of the furnace is concerned, the brick forming the sole being built into the masonry. This arrangement will not suffice, though, for the front, since the charging and discharging of the mineral is made on that side through doors opening upon each sole. To obviate this difficulty an interval is left between the front of the sole and the wall, which interval at the time of charging the lower sole is filled with slack, held in place by a closed register. In charging the second sole the slack is let down and forms a "talus" upon the level below. The different levels are charged in this way, successively, from bottom to top. The furnace is charged once in thirty-six hours, and consumes 1,000 kilog. of fine pyrites. As the charging cannot be done in an instant it permits the passage of an excess of air, while it is going on, and possibly this may explain the fact, denied by some, but maintained by many, that this system of furnace requires an excess of nitrate for the amount of sulphur burned.

Altogether these improvements, and the possession of extensive deposits of cupriferous pyrites at Chessy and Saint-Bel, have given a great development to the manufacture of MM. Perret. Their establishment at Chessy, Lyons, Vienna, Avignon and Marennes, furnish nearly 100,000 kilogrammes of acid a day, beside the other products derived from them, such as soda, iron, copper, alum, ammonical salts, hydrochloric and nitric acids, soda, &c., &c. Such an impetus has been given to general industry, in consequence of the discoveries of the firm of Perret Brothers & Olivier, that even their enormous present production of acid is insufficient, and fully twice the amount of pyrites consumed by them has been delivered to French and other consumers for manufacture by this process. In renouncing the monopoly assured to them by the possession of their extensive ore beds, this firm have entered upon a path of liberality which cannot fail to advance greatly the industrial interests of the whole nation, and have set an example most worthy of imitation.

Steam Plowing in France.—At the special trial of agricultural implements at Moulins, in April, the double engine tackle of Messrs. Aveling and Porter took the first prize, and the second prize was awarded to M. Achille Farjas. The next trial takes place this month at Beauvais. The French are imitating the English in these comprehensive and frequent tests.

NOBEL'S BLASTING MATERIAL.

NEW EXPERIMENTS WITH "DYNAMITE."

Reported by Max v. Wolfskron.

Translated from "Oestr. Zeitschrift."

Mr. Nobel's nitro-glycerine, which produces such powerful and astounding effects, has on the other hand caused so many fatal accidents, that a certain awe of its dangerous qualities has prevented it from coming into general use. It is true, there are countries, as for instance Bavaria, where for several years past nitro-glycerine has been used for blasting, without the occurrence of any mishaps; and indeed such accidents can scarcely happen unless by neglect of the necessary precautions. But it is well known that workmen when once familiar with a work that implies some danger, become very careless, and that this carelessness often causes the most fearful accidents. Besides the nitro-glycerine, like all similar compounds of nitrogen, is in itself liable to be decomposed, when the acids produced by this decomposition affect and loosen the soldering of the metallic bottles which contain the fluid nitro-glycerine, thus causing leakage and danger. It is also not impossible that under certain circumstances a spontaneous decomposition of the fluid may take place so rapidly as to produce an explosion. Therefore, whenever it is observed that nitro-glycerine is beginning to decompose, which is easily seen by the red vapors it then emits, the whole portion should be destroyed without delay.

It is not astonishing that the importation and the transport of so dangerous a material should have been prohibited in several countries, and also in Austria. But there was no well-founded reason to include in this prohibition, as it has been done, another matter, called dynamite, which does not possess the above-mentioned dangerous qualities. Dynamite consists of calcined mineral meal from the neighborhood of Lüneburg (Prussia), impregnated with 75 per cent of nitro-glycerine, and mixed with another ingredient, which prevents it from spontaneous ignition. It hardens at 45° F., at which temperature the nitro-glycerine contained in it, congeals. In this condition it cannot be exploded by ordinary means. Charges congealed in the bore-holes must be exploded by caps and cartridges having a higher temperature than 45° F. These cartridges, which also contain the caps, are small, and the workmen can easily carry them in their pockets.

Dynamite has been manufactured at Hamburg by Mr. Nobel, since 1866, and more recently also at Stockholm, in Sweden. In the latter country the dynamite is in general use in the mines and quarries. In Prussian Silesia 8,000 lb. of it are used every month. It is besides largely in use in the mines of Saarbruck, Westphalia, Nassau and Thuringia. Considerable quantities of it have been imported to England and Belgium, in 1868.

A factory of dynamite was established in San Francisco in March, 1868, which factory had already sold 100 lb. of it per day, up to July of the same year. It is used not only in the mines of California, but also in those of Mexico, and in the blasting operations of the Pacific railroad. In California also, as in several European countries, accidents were feared from this new blasting material, and no company would at first undertake its transportation. But afterwards, when various experiments, made before an assembly of representatives of all the transport companies, had proved that these fears were groundless, the dynamite was accepted on all the railroads, steamers and stage-coaches.

The following experiments, for the same purpose, were made on the 22d of March at Hütteldorf (Austria) in presence of a delegation of the Vienna Society of Engineers: A small barrel, filled with cartridges of dynamite, was thrown down from a rock over 100 ft. high and did not explode, though striking the rock repeatedly. Two cartridges were fastened to the lower surface of a heavy block of stone, and the stone was dropped from a hight of over 20 ft. on a stone bottom. The cartridges were smashed and flattened down without exploding, and the dynamite was found in a totally unaltered condition.

Several cartridges were taken out of the above-mentioned barrel; each cartridge was cut in two parts, the one of which was made to explode by the means of a quick-match and a cap; the other part was ignited, and burned off quietly, leaving a small heap of mineral meal.

The contents of a cartridge was spread over a piece of sheet-iron and heated; the nitro-glycerine evaporated without explosion.

A box of sheet-iron, filled with dynamite, was thrown into the fire without producing an explosion. The above-mentioned barrel, filled with cartridges was thrown into the fire, and burned down quietly.

To show that the dynamite cannot be made to explode, except by a strong cap, it was tried to ignite a box of sheet-iron, filled with dynamite, by a quick-match without a cap; but the dynamite would not take fire.

These experiments having proved sufficiently that the dynamite is entirely void of danger, another series of experiments was made to show the powerful effects of this new blasting-material:

A cartridge was laid on a plank of maple-wood, two inches thick, and was made to explode. It struck the plank with great vehemence, making a large hole through it.

As the strange prejudice exists that the dynamite acts better downward than upward, the same experiment was repeated, the cartridge being this time attached to the lower surface of the plank. The effect was the same.

A timber, four inches by five inches thick, rammed into the ground, was torn apart by the discharge of a half-pound cartridge.

Half a pound of dynamite was made to explode on an iron plate a quarter of an inch thick. The plate became perforated and torn; a round piece was torn out of it and thrown to a considerable distance.

But the immense power of the dynamite was proved most strikingly by the following experiment;

A $\frac{7}{8}$ inch hole was bored through the whole length (13″) of a wrought-iron cylinder of 8 inches diameter. This bore-hole was filled with one-quarter of a pound of dynamite and discharged by a Markus battery. The effect was astonishing to a high degree. The cylinder was torn in two pieces. Each piece had two cracks through its entire length, and many smaller ones. The bore was enlarged throughout, in one place to $1\frac{3}{4}$ inch. diameter. The molecular structure of the pieces was totally altered.

The succeeding experiment consisted in bursting a piece of rock without any bore-hole.

Finally, four bore-holes, $1\frac{1}{2}$ inches in diameter, and 3 ft., $2\frac{1}{2}$ ft., 2 ft., and 16 inches in depth, made into the solid rock, were discharged without tamping. The first hole was loaded with 2 pounds, the second with 10 ounces, the third with 8 ounces; the fourth, which was made in the vault of the rock, with only one ounce. The first and third were discharged simultaneously by the Markus battery; after that the second hole alone by the same battery, which also on this occasion proved its excellence. The fourth bore-hole was discharged by a gutta-percha quick-match. The effect of these discharges was satisfactory, though the rock was soft and loose and consequently unfavorable for such experiments. S.

CONDENSATION IN STEAM ENGINES.

By M. E. Cousté, Government Director of Manuf.

Translated from "Annales du Génie Civil."

An important question has long troubled the wisdom of engineers in every country where steam navigation has received any development, viz, the use of steam at high pressures in marine engines. The greatest obstacle to its employment is the excessive incrustation of the boilers from the use of sea water. The English have essayed to solve the problem by the use of surface condensers, which make it practicable to supply the boilers with water, from which the incrustating matters have been eliminated. This contrivance rendered necessary an enormous area of condensing surface, resulting in practical difficulties similar to those which defeated the attempts of Watt, Hall, Cavè, Bourdon, Ericsson, and a host of other engineers. Latterly means have been found of giving to the surface condenser a superficies of more than a square meter per horse power, which has given some good results. I am convinced, however, and I shall attempt in this paper to prove that this solution, though constituting a sort of progress, is founded on a retrograde principle ; that it realizes but a portion of the advantages which may be obtained, and that those advantages cannot be obtained completely, and with certainty, except by the use of the injecting condenser.

I propose then—

(1.) To analyze the phenomena of condensation, by laying down the general, physical and mathematical theory of the condenser, which will enable us to determine the loss of motor power caused by the condensation.

(2.) To compare the two systems, viz, condensation by injection, and surface condensation, and to show that the former is greatly superior to the latter.

(3.) To determine in what respects the present injecting condenser is capable of important improvements.

(4.) To prove that the surface condenser is subject to perturbations, which diminish, and may even counterbalance, the advantages of high pressure.

I shall further show that the injecting condenser may be made applicable to high pressure marine engines, as well as to other steam motors, by an important modification, which I shall point out, in the functions of the condenser, and I shall describe the practical means of effecting its application.

(1.) There are two kinds of condensers. In the first the steam is brought directly in contact with the cold condensing water, which mingles inseparably with the condensed water. In the second the condensing water acts upon the steam through an intervening metal, which is a good conductor of heat, and also serves the important purpose of keeping the condensing and condensed waters separate. The former is called the injecting condenser, and is the kind most frequently employed. The latter is called the surface or Hall condenser, and until quite recently had been employed only in certain special engines (ether, chloroform, alcohol engines), which are not yet out of the domain of experiment.

(2.) I shall first proceed to determine a general formula expressing the resistance of the condenser. The act of condensation is not accomplished instantly, but requires a certain length of time. If L represent the stroke of the piston, n L will be that part traversed by the piston while the condensation is in progress. Let

T m be the motor power, or work developed by the steam at each stroke.

T c i be the resistance of the injecting condenser.

T c s be the corresponding resistance of the surface condenser.

T c be the corresponding resistance of a condenser of either system (the general expression of resistance).

T a be the resistance of the air pump.

S be the area of piston of cylinder (in sq. centimeters).

L be the stroke in meters.

E be the part of the stroke during which the steam enters with a full pressure.

P be the pressure (in kil. per sq. cent.) after expansion, and at the instant of opening communication with the condenser.

H be the pressure before expansion.

p be the normal pressure in the condenser ; *i. e.*, the pressure which remains after the condensation is finished (in kilog. per sq. centimeter).

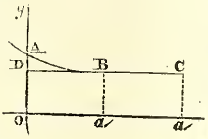
n L be the fraction of the stroke during which the condensation is in progress.

r be the ratio of the capacity v of the condenser (including its connections) to the capacity V of the cylinder (including the volume occupied by the piston and the clearance spaces, thus,

$$r = \frac{\text{condenser}}{\text{cylinder}} = \frac{v}{V}.$$

As soon as the communication is opened

between the cylinder and condenser, the pressure P, corresponding to the volume V, becomes $\frac{\text{P V}}{\text{V} + v}$. At the same instant the pressure p, which corresponds to the volume v, becomes $\frac{p\,v}{\text{V}+v}$. At that instant therefore the pressure in the condenser is $\frac{\text{P V} + p\,v}{\text{V} + v}$, or $\frac{\text{P} + p\,r}{1 + r}$. During the part of the stroke n L this pressure diminishes (at a rate corresponding to the condensation), passing from $\frac{\text{P} + p\,r}{1 + r}$ to p; and during the part $(1 - n)$ L it remains equal to p. Let us represent the successive values of this pressure by the ordinates to a curve. Let $x'' = \text{O}\,a' = \text{L}$, $x' = \text{O}\,a = n\,\text{L}$, $a\,a' = (1 - n)\,\text{L}$, $y\,o = \text{O A} = \frac{\text{P} + \text{P}\,r}{1 + r}$. $y' = a\,\text{B} = a'\,\text{C} = p$.



The portion B C of the line will be straight and parallel to the axis of x; the portion A B will be curved and tangent to B C at the point B.

T c will be represented by the surface S of the piston multiplied by the area A O a' C. The area of D O a' C = L p. To express the other part of the area, we must know the curve A B. In this particular case we may determine it approximately by the Watt indicator, and in this general analysis we shall replace it by an approximation sufficiently accurate, if we use the arc of a parabola, having its vertex at B, passing through A, and having its axis parallel to the axis of y. This arc will in general differ immaterially from the true curve. Hence the part A D B of the total area will be $\frac{1}{3}\,\text{A D} \times \text{B D} = \frac{1}{3}\left(\frac{\text{P} + p\,r}{1 + r} - p\right)\,n\,\text{L}$ $= \frac{1}{3}\,\text{L}\,\frac{\text{P} - p}{1 + r}n$. The total area is then $\frac{1}{3}\,\text{L}\left(\frac{\text{P} - p}{1 + r}\,n + 3\,p\right)$, and the *work* of the condenser is

$$\text{T}\,c = \tfrac{1}{3}\,\text{S L}\left(\frac{\text{P} - p}{1 + r}\,n + 3p\right). \quad (1)$$

This expresses the *resisting work* of the condenser, so far as relates to the counter-pressure alone; and if we simply add the deduction due to the work T a of the air pump, we shall obtain the whole resistance of the apparatus. The formula (1) is applicable to both kinds of condensers, and we shall transform the expression further on, so as to introduce the peculiar elements of both.

(3.) First, however, it is necessary to consider the values, both arbitrary and necessary, which the quantities designated above may take.

T a is a quantity nearly constant, as applied to a given engine, varying very slightly with the quantity of water to be drawn, with the slight counter-pressure of the condenser, and the slight variations of atmospheric pressure. But when the building of an engine is contemplated, it is a matter of no small moment to design it so as to employ the minimum of water, whether the object be to economize it on account of its small supply, or to diminish the effect of T a, which depends for its value chiefly upon the area of the pumping piston.

(4.) The value of P will depend upon the initial pressure H of the steam when it enters the cylinder, and upon the rate of expansion allowed. It is an advantage to give this expansion its greatest practicable amount. L and S being constant in a given engine, the expansion will be limited by the amount of useful effect which can be produced in a given time; and as this latter quantity can be made to vary, its variation should be regulated entirely by the cut-off, which may work automatically or at control of the engineer. But we are of the opinion that, other things being equal, the range of expansion will be extended in proportion as the pressure is increased, and hence the advantage (which is considerable) of employing steam at high pressures.

(5.) The pressure in the condenser passes, as we have said, through different values during the stroke of the piston. For a given value of P, and for a single quantity of water introduced, the condensation will be effected in a time equal to, or less, or greater, than the duration of the stroke of the piston. In the first instance the pressure in the condenser will reach the *normal* value p before the end of the stroke; in the second p will be reached just at the conclusion of the stroke; in the third case the value of p must be increased to p', in order that the normal pressure may be reached during the time of the stroke. We must therefore give to p just the value which the normal pressure has at the instant the stroke is completed. It will be observed that p is the sum of two pressures—the one f due to the steam (watery vapor) which remains normally in the condenser, the other f due to the gases given off by the condensing and feed water, and to the air which may find access by leakage. In an apparatus properly managed and cared for, and built upon correct principles, there ought not to be any leakage. The gases given off by the feed waters of the boilers are insignificant in well managed engines, because that water is drawn from the condenser itself, and has already been freed from the greater part of its gases. We may then proceed to determine f and f'.

In a particular case we might determine f by means of a table of the elastic forces of vapors, and according to the normal temperature of the condenser. But we must note that this temperature is really higher than that of the water taken from it, because the contact of the condensing water and the steam is of short duration, and only partial—the water not being generally in a sufficiently divided state to establish a thermal equilibrium in so short a time. In order to determine it the thermometer should be placed in a part of the condenser opposite the entrance of the steam, and protected from the injected stream. The quantity f being thus obtained, we shall have f' by deducting $p-f$; and the value of p will be given by the manometer of the condenser.

(6.) But it will be advisable to introduce into eq. (1) the value of p as a function of the normal temperature of condensation, θ of the temperature, t of the cold water, and of the volume q of the water resulting from the condensed steam at each stroke of the piston.

We shall then have (according to Southern)—

$$f = A + \left(\frac{B+\theta}{C}\right)^{5.13}; \quad A = 0.0034542 \quad B = 46,278 \quad C = 145.36$$

Also let

$\theta =$ the temperature of the condenser corresponding to the elastic force of the steam f.

$t =$ the temperature of the injected cold water.

$\frac{1}{m} =$ the proportion (in volume) of gas which that water contained.

$Q =$ the volume of cold water theoretically necessary for injection at each stroke of the piston.

$q =$ the volume of water resulting from the condensation of the steam at each stroke.

$$\text{Then, } Q = q\,\frac{650-\theta}{\theta-t}.$$

But in the injecting condenser this quantity Q should be doubled in practice. The volume of gas introduced into the condenser at each stroke of the piston is then (at the pressure of 1 atmosphere)

$$\frac{2\,Q}{m} = \frac{2\,q}{m}\cdot\frac{650-\theta}{\theta-t},$$

at the temperature t, and at the temperature θ of the condenser is $\frac{2\,q}{m}\cdot\frac{650-\theta}{\theta-t}\cdot\frac{274+\theta}{274+t}$

The pressure of this gas is that of the atmosphere, 1.03 kilog. per square centimeter under the volume given above, and becomes, under the volume v of the condenser,

$$f' = \frac{2.06}{m}\cdot\frac{q}{v}\cdot\frac{650-\theta}{\theta-t}\cdot\frac{274+\theta}{274+t},$$

$$\text{Hence, } p = A + \left(\frac{B+\theta}{C}\right)^{5.13} + \frac{2.06}{m}\cdot\frac{q}{v}\cdot\frac{650-\theta}{\theta-t}\cdot\frac{274+\theta}{274+t}\ldots \quad (2)$$

(7.) The quantity n varies in consequence of some circumstances which it is well for us to examine.

The escape of the steam from the cylinder to the condenser, though very rapid on account of the difference of the two pressures, is by no means instantaneous. The connections are always ample, of course, but the opening of the ports is, during a portion of the valve movement, partially obstructed. This becomes apparent on the diagrams by a rounding off of the angles where the piston changes its motion, and by the rapid fall of the pressure just before the instant of cut-off. But in well built injecting condensers this partial cause of retarded condensation may be neglected, especially if the velocity of the piston be not excessive. It must not, however, be neglected in surface condensers, because the condensing surfaces usually consist of tubes of small diameter, among which the steam circulates with some difficulty, especially when it encounters a certain amount of air and other permanent gases.

Secondly, the cold water is introduced in the form of jets more or less divided, offering a certain amount of surface of direct contact to the steam. Water being a poor conductor of heat, an equilibrium takes place almost at the instant of contact of the steam with the water of the jets, and that collected in the bottom of the chamber—the walls of the chamber also taking part in the operation. But all these surfaces are heated by the condensation, and their condensing power correspondingly reduced; and as they are only partially cooled again by succeeding movements, it would appear that their action cannot be instantaneous in destroying the difference between the pressures P and p.

(8.) Let us take the general expression $x = \frac{L}{2}(1 - \cos \tilde{\omega})$ for the space passed over by the piston for any angle $\tilde{\omega}$ described by the rotation of the crank—neglecting the small variations arising from the variable position of the connecting rod. The angular velocity of the crank being constant, $\tilde{\omega} = \tilde{\omega}' \frac{\tau'}{\tau}$; or, taking for the angular unit $\tilde{\omega}' = 180°$, then $\tilde{\omega} = \frac{\tau'}{\tau}$; in which equation τ' = the time corresponding to x, and τ = the time of a whole stroke of the piston. Then

$$x' = \frac{L}{2}\left(1 - \cos \frac{\tau''}{\tau}\right)$$

τ'' being the time corresponding to x', and

$$\frac{x''}{L} = n = \tfrac{1}{2}\left(1 - \cos \frac{\tau''}{\tau}\right).$$

We assume τ' and τ to be expressed in seconds.

Let Φ express the rapidity of the absorption of heat by the condenser, *i. e.*, the quantity absorbed in one second ; then $\tau'' \Phi$ will be the quantity absorbed during the whole process of condensation. The expression for this quantity is D $q\,(650 - \theta)$; D being the density of the water, and assuming D =1, then

$$\tau'' = \frac{q\,(650 - \theta)}{\phi}.$$

Substituting this,

$$n = \tfrac{1}{2}\left[1 - \cos \frac{q\,(650 - \theta)}{\tau\,\phi}\right]$$

Now we may put $\Phi = R\,\phi$, R being a co-efficient < 1, depending partly upon the resistance due to the pressure of air, and partly upon the friction of the steam, whether in the connections of the general condenser, or in the tubes of the surface condenser. ϕ will be composed, first, of heat transmitted through the walls or skin of the condenser, and expressed by

$$a = \kappa\,\tau\,\frac{a' - b}{e} \quad . \quad . \quad . \quad . \quad (3)$$

in which

κ = the co-efficient of conductibility of the walls; that is, the quantity of heat which passes in 1″ of time through one sq. met. of this wall, with an assumed thickness of one millimeter and for a difference of 1° of temperature between the two sides of the wall.

σ = the surface of each of these two sides.

a' = the mean temperature of the inside.

b = the mean temperature of the outside.

Second—There also enters into the value of ϕ the heat β absorbed by the water collected at the bottom of the condenser.

Third—The heat absorbed by the injected cold water.

This last quantity, by far the greatest, will be expressed by $\mu\,\Sigma\,(\Theta - t)$, in which

μ = the exterior conductibility of the water, or the quantity of heat which enters in 1″ of time into one sq. meter of aqueous surface, for a difference of 1° between the temperature of the water and of the steam.

Σ = the surface of the jet in sq. met.

Θ = the mean of the temperatures through which the condenser passes during a stroke of the piston.

t = the maximum temperature of the injected water.

We may then place as the general value of n,

$$n = \tfrac{1}{2}\left\{1 - \cos \frac{q\,(650 - \theta)}{R\,\tau\,[a + \beta + \mu\,\Sigma\,(\Theta - t)]}\right\} \quad (4)$$

(9.) For the sake of brevity let us place

$$M = \frac{2.06}{m} \cdot \frac{650 - \theta}{\theta - t} \cdot \frac{274 + \theta}{274 + t}.$$

also;

$$f = A + \left(\frac{B + \theta}{C}\right)^{5.13}$$

and substituting in eq. (1) these values, and the value of n, as given above,

$$T\,c = \tfrac{1}{3}\,S\,L\left[\left(P - f - M\,\frac{q}{v}\right)\tfrac{1}{2}\,\frac{1}{1+r} \times \left(1 - \cos \frac{q\,(650 - \theta)}{R\,\tau\,[a + \beta + \mu\,\Sigma\,(\Theta - t)]}\right) + 3\left(f + M\,\frac{q}{v}\right)\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

This equation is general and applicable to both kinds of condenser—cancelling the term $\mu\,\Sigma\,(\Theta - t)$ when it is applied to the surface condenser. In the injecting condenser we may also suppress a and β as being inconsiderable compared with $\mu\,\Sigma\,(\Theta - t)$. In reality the external and internal surfaces of this condenser are always incrusted or oxidized, and the latter is also always protected by a tissue of stagnant water—circumstances which diminish considerably the conducting power of the walls. It is otherwise plain that β is a very inconsiderable quantity, because the warm water in the bottom of the condenser exposes to the steam only its upper or warmer surface, while its interior conducting power is very small.

For the injecting condenser then we may place

$$T c i = \tfrac{1}{3} S L \left[\left(P - f - M \frac{q}{v} \right) \tfrac{1}{2} \cdot \frac{1}{1+r} \times \left(1 - \cos \frac{q(650-\theta)}{\tau \mu \Sigma (\Theta - t)} \right) + 3 \left(f + M \frac{q}{v} \right) \right] \quad (6)$$

We have assumed $R = 1$. We shall also have occasion to equate the value of $T c i$ in the forms,

$$T c i = \tfrac{1}{3} S L \left[(P - p) \frac{1}{1+r} \cdot \tfrac{1}{2} \left(1 - \cos. \frac{q(650-\theta)}{\tau \mu \Sigma (\Theta - t)} \right) + 3 p \right] \quad . \quad . \quad . \quad (7)$$

$$T c i = \tfrac{1}{3} S L \left[\frac{P - p}{1 + r} n + 3 p \right] \quad . \quad . \quad (8)$$

We will put this expression into another form, which will show more clearly the influence of the surface Σ. Let Σ' be such a value of this surface that the duration of the condensation may equal that of a stroke of the piston, or so that $n = 1$. We shall then have in eq. (4), in which a and β are suppressed and $R = 1$,

$$n = \tfrac{1}{2} \left[1 - \cos \frac{q(650-\theta)}{\tau \mu \Sigma' (\Theta - t)} \right] = 1$$

$$\text{whence } \cos \frac{q(650-\theta)}{\tau \mu \Sigma' (\Theta - t)} = -1.$$

in other words

$$\text{arc } (\cos = -1) = \frac{q(650-\theta)}{\tau \mu \Sigma' (\Theta - t)} \text{ or,}$$

$$1 = \frac{q(650-\theta)}{\tau \mu \Sigma' (\Theta - t)}. \quad . \quad . \quad (9)$$

Deducting from this equation the value of q and substituting it in eq. (7), we have

$$T c i = \tfrac{1}{3} S L \left[(P - p) \frac{1}{1+r} \cdot \tfrac{1}{2} \left(1 - \cos \frac{\Sigma'}{\Sigma} \right) + 3 p \right]. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

It is obvious that this formula is applicable only for values of Σ greater than, or at least equal to, Σ'; for if we assume a value for Σ lower than Σ', it would be equivalent to supposing that the condensation would take place at a normal temperature θ' higher than θ.

(10.) It may be remarked that all these expressions of work consist of two elements; one expressed by the first term, which is the work due to the retardation of the condensation, or its duration, and the other due to the normal counter-pressure. I purpose discussing these quantities separately, beginning with the counter-pressure.

(11.) In principle there is no maximum rate of injection. On the subject of normal counter-pressure there is a prevalent opinion that the volume of gases introduced increasing with the quantity of water, there is, for each kind of water and condenser, a rate of injection to which there corresponds a minimum counter-pressure. This is true, but it is the result of imperfections in condensers, and not of injecting condensation as a principle, as we shall prove.

We have taken (§ 6)

$$p = A + \frac{(B + \theta)^{5.13}}{C} + f';$$

f' being the part of the pressure due to the gases brought by the condensing water. Eq. (2) expresses the value of p in ordinary condensers, where, as we have already remarked, it is necessary to inject about twice the quantity theoretically necessary, $\left(Q = q \frac{650 - \theta}{\theta - t} \right)$ on account of the imperfect mixture of the water with the steam. If we suppose the mixture to be perfect, then the equation

$$Q = q \frac{650 - \theta}{\theta - t} \quad . \quad . \quad . (2a)$$

expresses the quantity effectively injected, and the temperature, and may be used to determine either one of these quantities in terms of the other.

On this supposition, in place of eq. (2), we have

$$p = A + \left(\frac{B + \theta}{C} \right)^{5.13} + \frac{1.03}{m} \cdot \frac{q}{v} \cdot \frac{650 - \theta}{\theta - t},$$

supposing the factor $\frac{274 - \theta}{274 - t} = 1$, which is approximately true in practice.

Replacing θ by its value deduced from the above

$$\theta = \frac{650 + t \frac{Q}{q}}{1 + \frac{Q}{q}}, \quad . \quad . \quad . \quad (2b)$$

we shall have

$$p = A + \left[\frac{B}{C} + \frac{650 + t \frac{Q}{q}}{C \left(1 + \frac{Q}{q} \right)} \right]^{5.13} + \frac{1.03}{m} \cdot \frac{Q}{v}$$

Differentiating and placing $\frac{d p}{d Q} = 0$,

$$\frac{d p}{d Q} = 0 = -5.13 \left[\frac{B}{C} + \frac{650 + t \frac{Q}{q}}{C \left(1 + \frac{Q}{q} \right)} \right]^{4.13} \cdot \frac{650 - t}{C \left(1 + \frac{Q}{q} \right)^2} \cdot \frac{1}{q} + \frac{1.03}{m} \cdot \frac{1}{v} \quad . \quad (2c)$$

It is from this equation that we may deduce the value of Q which will give the minimum value of p. We shall proceed, then, to show that, within practical limits, there is no value of Q which will satisfy this equation.

1st. It is impracticable to condense beyond 100°, and it is rarely advantageous to condense below 20°, which corresponds to a tension of 1.70 centimeters of mercury, which should be at least sufficient to raise the valves of the air and water pump. According to eq. (2 b) the values of $\frac{Q}{q}$ corresponding to 100° and 20° respectively, are (supposing $t = 10°$) 6.1 and 63.

2d. The value of m is hardly greater than $\frac{1}{20}$, and we will therefore take it at that value.

3d. q depends upon the pressure H of the steam before cut-off, and the quantity E, the part of the stroke during which steam is admitted. H varies between 1 and 10 atmospheres, and E between $\frac{1}{15}$ and $\frac{1}{2}$. Hence we have $q = \frac{u}{\triangle}$; (u being the volume of steam introduced, and $\triangle$ the specific volume of its resultant water at the pressure H.

For H = 1 atmos. and E = $\frac{1}{2}$ we find

$$u = \frac{V}{2} \text{ and } \triangle = 1700;$$

whence

$$q = \frac{V}{1700 \times 2}$$

For H = 8 atmos. and E = $\frac{1}{15}$, we find

$$u = \frac{V}{15} \text{ and } \triangle = 254;$$

whence

$$q = \frac{V}{254 \times 15}.$$

4th. The volume of the condenser v varies between $\frac{V}{5}$ and V. Introducing these values into eq. (2 c), as well as the values of B and C.

For $\theta = 100°$, or $\frac{Q}{q} = 6.1$,

we find for H = 8 atmos.

$$-5.13\left[0.33 + \frac{650+61}{145 \times 7.1}\right]^{4.13} + \frac{640}{145 \times 7.1^2} \times \frac{254 \times 15}{V} + \frac{1}{V} 1.03 \times 20 = -1714\frac{1}{V} + 20.6\,\frac{1}{V};$$

a result with a *negative sign.*

For $\theta = 20°$ or $\frac{Q}{q} = 63$,

we find for H = 8 atmos.

$$-5.13\left[0.33 + \frac{650+630}{145 \times 64}\right]^{4.13} \times \frac{640}{145 \times 64^2} \times \frac{254 \times 15}{V} \times \frac{1}{V} 1.03 \times 20 = -171.14\,\frac{1}{V} + 20.6\,\frac{1}{V},$$

a result also with a negative sign.

It is clear that the results will continue to be negative in the case where the expansion E is $\frac{1}{2}$, and *à fortiori* in any case where it is expressed by a smaller fraction between $\frac{1}{2}$ and $\frac{1}{15}$. It is also plain that the results will be negative for pressures H lower than 8 atmospheres, since, in the negative term, which alone is a function of the pressure, the factor 254 will be replaced by numbers exceeding that factor, in proportion as H diminishes. Hence the equation (2 c) admits of no roots for values of the variable corresponding to normal temperatures between 20 and 100 degrees; in other words, there is no minimum of pressure between these limits. We therefore infer that we may advantageously bring the normal temperature θ of the condenser as near to that of the cold water as the circumstances of each particular case will warrant; regard. being had to the manner of disposing of the water. The vacuum has then no limit except the residuary force necessary to lift the valves of the air and water pumps. It will be readily seen, from a particular example, that with the cold water at 10° to 15° (since we can practically obtain only a vacuum indicated by 6 to 7 cent. of mercury, let $\theta = 45°$), we can, by suitably increasing the rate of injection, and supposing that we can always obtain a complete mixture of water and steam—we can, I say, reduce θ to 20° or 25°, and therefore reduce P to 2.8 or 2. cent. of mercury.

I conclude, then, that that portion of the work of the injecting condenser due to the normal counter-pressure p S L can be reduced from .093 S L, corresponding to a vacuum of 7 cent. of mercury, to .027 S L corresponding to a vacuum of 2 cent., making a reduction of say 71 per cent.

(12.) In formula (7) the first term is always positive, since P is always greater than p; otherwise the piston would be stopped before the end of the stroke; or if it continued its motion by virtue of the inertia of the machinery, the living force of the latter would be diminished, so as to interfere with the regularity of the movement of the engine, and without any compensating advantage. This shows that the cut-off may be carried too far to allow of an efficient condensation. Hence, other things being equal, if we make r vary, the work T c i will diminish proportionally to $(1+r)$. Again, $\cos \frac{q\,(650-\theta)}{\tau\,\mu\,\Sigma\,(\Theta-t)}$ increases from -1 to $+1$, according as τ and Σ, or either of these two, increase. It appears from eq. (17), which follows, that the term expressing the work due to the retard of the condensation is in the inverse ratios of τ^2 and Σ^2. Hence the inferences, that it is advantageous to increase as much as practicable the vacuum space of the condenser; to give the injected jet of water the largest possible surface Σ; and to increase as much as possible the length of stroke of the piston.

(13.) The first of these conditions seems to have escaped the attention of engineers and builders. The only point upon which they have been preoccupied in this particular is to increase in some measure the capacity of the condenser, with the object of diminishing the back pressure of the gases; persuaded, no doubt, that the condensation is instantaneous. But eq. (6) shows that T c i varies not only by the quantity $M\frac{q}{v}$ relative to the pressure of the gases, but still more by the factor $(1+r)$. In fact the rule generally adopted for the capacity of the condenser, is to make it between $\frac{1}{4}$ and $\frac{1}{5}$ that of the cylinder for single acting engines, and $\frac{1}{8}$ for double acting.

M. Farcot has deviated from this rule in the engines of the Imperial manufactory of Gros-Coillon, which have a condenser equal to the cylinder in capacity. We believe we can recommend his variation. We will show the importance by an example. Take a particular case, where P = 1 at. = 1.03 k.; $p = 0.1$ at. = .103 k. Take formula (8), where $n = 1$. Substituting, we have

$$T\,c\,i = S\,L = \left(\frac{.309}{1+r} + .103\right)$$

Make successively $r = \frac{1}{8}, \frac{1}{5}, 1, 2.$ Then

$$T\,c\,i^{(\frac{1}{8})} = .377\ S\ L$$

$$T\,c\,i^{(\frac{1}{5})} = .360\ S\ L$$

$$T\,c\,i^{(1)} = .257\ S\ L$$

$$T\,c\,i^{(2)} = .206\ S\ L$$

and substituting

$$\frac{T^{(\frac{1}{8})} - T^{(1)}}{T^{(\frac{1}{8})}} = \frac{120}{377} = .32.$$

$$\frac{T^{(\frac{1}{8})} - T^{(2)}}{T^{(\frac{1}{8})}} = \frac{171}{377} = .45.$$

$$\frac{T^{(\frac{1}{5})} - T^{(1)}}{(T^{(\frac{1}{5})}} = \frac{103}{360} = .28.$$

$$\frac{T^{(\frac{1}{5})} - T^{(2)}}{T^{(\frac{1}{5})}} = \frac{154}{360} = .42.$$

Hence, in an engine expanding till the pressures becomes 1 atmosphere, condensing at 0.1 at., and where the duration of the condensation equals the time of a stroke of the piston,

1st. The condenser having a vacuum capacity of $\frac{1}{8}$ the volume of the cylinder, ($r = \frac{1}{8}$), if it be replaced by another equal to the volume of the cylinder ($r = 1$), then the work T c i will diminish 32 per cent. If replaced by one double the volume of the cylinder, T c i will diminish 45 per cent.

2d. The condenser having $\frac{1}{5}$ the volume of the cylinder, if the same substitutions are made, T c i will diminish in the first case 28 per cent, and in the second 42 per cent.

(14.) As to the second inference (No. 12), no importance has heretofore attached to it, though it possesses a great deal. The water is brought into a receiver placed beside the condenser, whence it flows into the latter by means of atmospheric pressure through a common nozzle, with no provision, however poor, for dividing the jet. It will be well to examine the influence of Σ upon the work of the condenser.

Let P = 1.03 k., $p = .103$ k., $r = \frac{1}{5}$, and taking eq. (10),

$$T\,c\,i = S\,L\left[.128\left(1 - \cos\frac{\Sigma'}{\Sigma}\right) + .103\right]$$

it will be seen that, if Σ be only slightly increased, T c i will be only insensibly diminished. This last remark explains why we obtain no improvement in the vacuum, practically, by increasing the admission of water beyond a certain degree; for though we increase the admission of water, we increase the surface of the jet very inconsiderably, and even this slight increase is counterbalanced, or even more, by the increase in the quantity of gases brought in. But suppose that, by means which I shall indicate, we could double, triple, quadruple, centuple Σ; the differences between the values of $T\,c\,i$ would become very perceptible. For instance, make successively $\Sigma = \Sigma'$; $10\ \Sigma'$; $100\ \Sigma$; then

$$\overset{(1)}{T\,c\,i} = S\,L\,[.128.2 + .103] = .359\ S\,L$$

$$\overset{(10)}{T\,c\,i} = .109\ S\,L$$

$$\overset{(100)}{T\,c\,i} = .1031\ S\,L,$$

and

$$\frac{\overset{(1)}{T\,c\,i} - \overset{(10)}{T\,c\,i}}{\overset{(1)}{T\,c\,i}} = \frac{.250}{.359} = .69.$$

$$\frac{\overset{(1)}{T\,c\,i} - \overset{(100)}{T\,c\,i}}{\overset{(1)}{T\,c\,i}} = \frac{.2559}{.359} = .71.$$

Hence, having an engine where the duration of the condensation equals the time of the stroke of the piston, where $\Sigma = \Sigma'$ or $n = 1$, if we increase tenfold the surface of the jet, the work will diminish 69 per cent, and if we increase it a hundredfold, the work will diminish 71 per cent.

(15.) Let us now inquire how the desired increase in the surface of the jet may be obtained, and within what limits it may be properly increased.

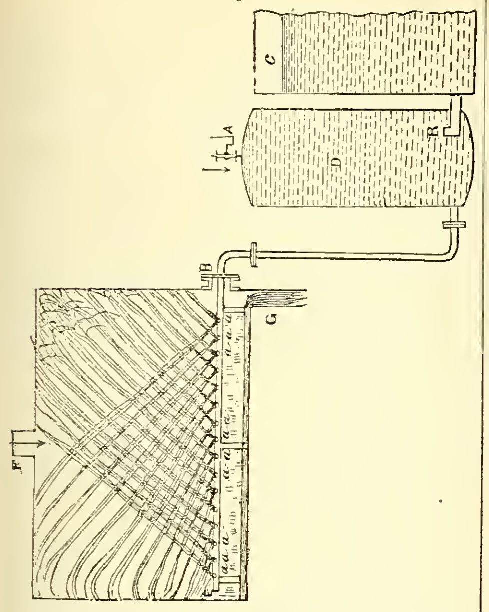
M. Sanial du Fay, a naval engineer, has devised a method of "pulverizing" the water, or reducing it to the form of spray, thus giving it a great amount of surface. This method consists in forcing the water through two converging nozzles, so that the two streams collide a short distance from the points of emergence, the result being a minute division of the water. The minuteness of the division increases with the pressure under which the water is forced. By this means a litre of water can be given 600 square meters of surface. The water enters the condenser in this comminuted condition, and the stream, mingling with it, obtains a great surface of contact—as it were, particle with particle. There results a sudden and intimate mixture, a very rapid condensation, and a perfect equilibrium of temperature between the water of the condenser (consisting of injected water, and water of condensation) and the normal vapor of the condenser.

(16.) Besides the advantage of rapid condensation, we also have the power of diminishing the actual rate of injection. Let us examine this.

1st. The quantity of water at the temperature t necessary theoretically to condense to the temperature θ is, for each stroke, $Q = q\ \frac{650 - \theta}{\theta - t}$. Generally the quantity of water required in practice varies between 1.75 Q and 2 Q. This is due to the fact that a considerable portion of the water escapes contact with the steam, and has no effect upon the condensation. Practically, on the one hand, the surface Σ of the jet is relatively small, and is but little increased by opening wider the injection valve. On the other hand, the water is kept flowing in a constant stream, while it should, on principle, diminish as the condensation goes on, and terminate with it. Hence it happens that the water issues from the condenser at a temperature below θ, and the condensation occupies the whole stroke of the piston. This is shown by the diagrams when they are drawn with care, and by the aid of an indicator sufficiently sensitive. To approximate the rate of injection to the theoretical rate there is requisite, not merely a rapid and intimate mixture of water and steam, but also an intermittent injection, lasting only during the time absolutely necessary for condensation.

With this view I propose the following arrangement. The cold water cistern, instead of being open, is to be closed and put into communication intermittently, at each stroke of the piston, with steam which surrounds the cylinder. This communication should last a little longer than the time requisite for condensation. The flow of the water will be effected by the pressure of the steam, and will cease the moment the communication is intercepted. Fig. 2 will give the idea substantially. D is the cistern, subject to intermittent pressure; A, a valve worked by the rod of the slide valve; E, injecting condenser; F, steam port opening into condenser; G, communication with air and water pump; a, Du Fay nozzles for comminuting the water; they are fixed in a copper pipe, which can be easily withdrawn in case of obstruction, and another replaced through the hole B; C, reservoir of cold water; R, check valve between the cistern and reservoir. When the valve A is open, the check valve R shuts; when it closes, R

Fig. 2.



is opened by atmospheric pressure, and the water expended from D is resupplied automatically by the reservoir C. By means of such an arrangement the actual rate of injection may be diminished so as not to exceed one-tenth the theoretical rate, which is, in effect, the use of water amounting to 1.1 Q in place of 1.75 Q — an economy of $\frac{.65}{1.75}$ or .37.

This economy may, in some cases, be a matter of no small consequence; indeed it may become highly important when water is in limited supply, or has to be pumped from a great depth, or when it is necessary to allow a high temperature in the condenser and consequent strong back pressure, or even to otherwise abandon the condenser altogether.

2d. In a case where this economy of water can be realized, instead of employing it to reduce the normal temperature θ, and consequently the back pressure of the condenser, we may reduce in the same proportion, viz, 37 per cent the volume of the air pump, and thus diminish sensibly the resisting work of this member. The work T a of this pump is

$$T\, a = O + (1.03 - p')\, s\, l;$$

an expression in which O is the work due to the exhausting of the water and air, and to friction; s, the area of piston in sq. cent.; l; the stroke; p, the mean pressure in the condenser during a stroke of the piston. Keeping in view the preceding, s may be replaced by

$$s' = s\,(1 - .37) = .63\, s$$

and substituting

$$T\, a = O + (1.03 - p')\, .63\, s\, l.$$

Allowing that O remains the same—a supposition not favorable to our case—then

$$\frac{T\, a - T'\, a}{T\, a - O} = 1 - .63 = .37.$$

(17.) The third condition mentioned in (§ 12) with reference to the duration of the stroke of the piston, seems to have received no attention in the various projected engines. This element of the problem has always been made subordinate to considerations having no reference to the development of power. This will be seen by the following tables, taken from examples given in the work of M. Gaudry, Traité des Machines.

It appears by these tables that the duration of the stroke varies between 0″.375 and 1″.200, and without any relation to the elements of motor power (pressure, diameter, and velocity of piston). It appears that it has been determined only after the diameter of the wheels or the pitch of the screw, with the view to obtaining a given

Names of Vessels.	Power.		Steam.		Piston.		Revolutions per minute.	Wheels.		Time of stroke, in seconds.
	Nominal.	Real.	Pressure, atmos.	Cut-off.	Stroke, meters.	Diameter, meters.		Diameter, meters.	Velocity per sec., meters.	
Parisien No. 2.	120	....	1.5	.60	1.00	1.25	34	4.63	8.239	.937
Parisien No. 4.	240	....	1.5	.70	1.20	1.45	34	4.70	8.836	.937
Papin No 9	125	....	4.0	.30	.91	.86	36	4.65	8.760	.833
Napoleon	120	148	6.0	.40	1.36	.56	36	3.95	7.460	.832
Express.	450	450	5.0	.25	1.20	1.20	35	5.30	9.707	.857
Papin No. 6.	260	....	3.5	.25	2.25	1.90	28	5.70	8.187	1.071

Names of Vessels.	Power.		Steam.		Piston.		Revolutions per minute.	Screws.		Time of stroke, in seconds.
	Nominal	Real.	Pressure.	Cut-off.	Stroke, meters.	Diameter, meters.		Pitch, meters.	Velocity of propeller.	
Encounter.	360	643	1.0	.75	.68	1.40	80	4.50	6.000	.375
Arrogant	360	623	1.0	.75	.60	1.40	60	4.50	4.500	.500
Niger	400	919	1.7	....	.45	.91	75	5.10	6.375	.400
Termagant, geared 2 to 1	620	1,351	1.5	....	1.06	1.24	36	5.40	6.520	.833
Napoleon, geared 2 to 1.	950	1,300	....	.80	1.63	2.42	25	9.38	7.816	1.200
Eylau.	900	....	2.5	.70	1.00	1.65	60	8.90	8.900	.500
Isly	650	....	2.5	.80	.80	1.56	55	8.00	7.333	.545
Chaptal.	220	340	1.0	.70	.70	1.00	70	6.40	7.467	.429
Primauguet	400	....	3.0	.30	.89	1.20	52	9.00	7.800	.576
Roland, geared 2 to 1.	400	....	....	.70	1.00	1.20	42	5.43	7.602	.714

velocity for the moving apparatus. In engines already constructed this duration can be modified only by changing the velocity of the piston, and this by diminishing or increasing the admission of steam. Under all circumstances where the resistance to be overcome will allow of a diminution of this velocity it will be advantageous to make it. But when we contemplate the construction of an engine, and observe that we can vary within certain limits the diameter of wheels and screws, the angular velocities, and the rate of gearing, we may realize the advantages of a long stroke of the piston. For example, the vessels Encounter, Niger, Arrogant, Termagant, whose strokes are respectively .375, .400, .500, .833 seconds, might have been so constructed as to make but 25 turns per minute, like the Napoleon, by means of suitable gearing or otherwise.

We may put eq. (7) under the form

$$T c i = \frac{1}{3} S L \left[(P - p)\frac{1}{1+r} \cdot \frac{q^2 (650-\theta)^2}{4 \tau^2 \mu^2 \Sigma^2 (\Theta - t)^2} + 3 p \right];$$

replacing the cosine by its value in terms of the arc, and stopping at the second term of the series, which gives this value. It will be seen that, all other things being equal, if we can vary the time of the stroke of the piston, the portion of the work due to the retardation of the condensation will diminish proportionally to the square of this time.

(18.) Resuming the principal results furnished by the discussions of the formulas relative to the injecting condenser, we make the following deductions.

1st. There is no maximum rate of injection. The vacuum of the condenser has no other limit than the weight of the valves of the air pump, and the portion of the work due to the normal counter-pressure can be reduced about 71 per cent.

2d. There is an advantage in increasing the vacuum space of the injecting condenser. By increasing it five times, the work due to the retardation of condensation will be diminished 28 per cent; increasing it ten times, it will be reduced 42 per cent.

3d. By injecting the water in a state of fine division, this same work may be reduced 71 per cent. If the second and third reductions are realized at the same time, their combined effect will be (calling $T r$ the work due to the retardation), $T r (1 - .42)(1 - .71) = 17\ T r$.

The total reduction then is $\frac{T r (1 - .17)}{T r} = 83$, or 83 per cent.

4th. The actual rate of injection may be reduced about 37 per cent.

5th. It is advantageous to make the time of the stroke of the piston as long as may be consistent with the work to be done.

(19.) To show the importance of the advantages resulting from the reductions of work just mentioned, it only remains to determine, by some examples, the relation between the resisting work of the condenser and the developed motor power. I shall do this, theoretically, by means of some formulæ I have obtained, and practically by the use of diagrams. drawn with great care by an ingenious contrivance made by M. Farcot. These diagrams were constructed by M. Demondiser, chief engineer of the government manufactories, figs. 3 to 11.

We may observe that, in each diagram the curve determines three areas, viz, the

Fig. 3.

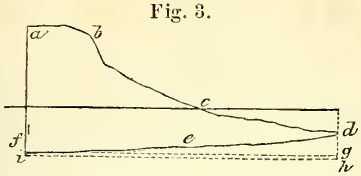


Fig. 4.

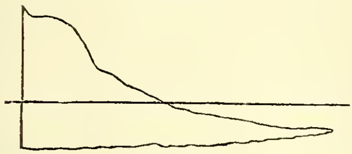


Fig. 5.

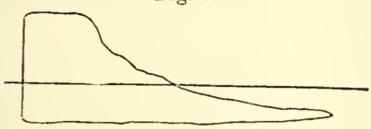


Fig. 6.

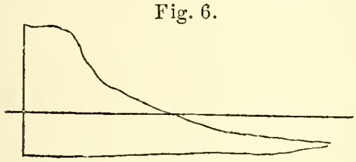


Fig. 7.

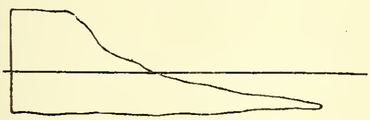


Fig. 8.

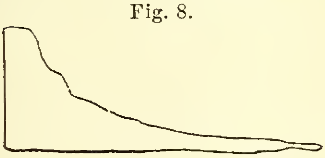


Fig. 9.

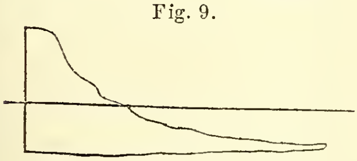


Fig. 10.

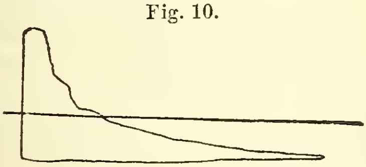
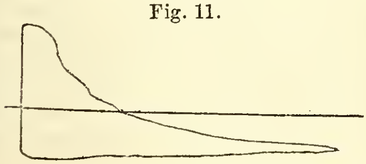


Fig. 11.



area *a b c d h i*, fig. 3, which represents the developed power per sq. cent. of surface of the piston; that is, the quantity

$$\frac{\mathrm{T}\,m}{\mathrm{S}} = \mathrm{H\ E}\left(1+l\frac{\mathrm{L}}{\mathrm{E}}\right);$$

the area *f g h i* representing the portion of the resisting work of the condenser due to the normal counter-pressure *p*, which I shall designate by T *p*; that is, the quantity

$$\frac{\mathrm{T}\,p}{\mathrm{S}} = p\,\mathrm{L};$$

and the area *d e f g* representing the other part of the work of the condenser due to the retardation of condensation, which I shall designate by T *r*; that is, the quantity

$$\frac{\mathrm{T}\,r}{\mathrm{S}} = \tfrac{1}{3}\,\mathrm{L}.\frac{\mathrm{P}-p}{1+r}\,n.$$

I give in the following table the values of $\frac{\mathrm{T}\,r}{\mathrm{T}\,m}$, $\frac{\mathrm{T}\,p}{\mathrm{T}\,m}$, $\frac{\mathrm{T}\,c\,i}{\mathrm{T}\,m}$, deduced separately from the aforementioned diagrams, from eq. (8), and also eq. (10), to a condenser modified conformably to the consideration in § 12–16.

The engine which furnished these diagrams made 29 revolutions per minute, and its condenser had a vacuum space one-fifth the capacity of the cylinder. The valves had but a very slight lead. In the diagrams the line of perfect vacuum was determined by the pressure *p* observed by the manometer of the condenser, and the portion of the initial ordinate below the atmospheric line. The values of *n*, introduced into eq. (8), were determined by the diagrams. As there was some uncertainty about the true position of the point of contact of the arc of the parabola with the line parallel to the atmospheric line, there resulted also some indecision as to the true values of $\frac{\mathrm{T}\,r}{\mathrm{T}\,m}$, and consequently of $\frac{\mathrm{T}\,c\,i}{\mathrm{T}\,m}$ deduced from that formula. It will be readily understood that the values deduced from the diagrams are still less precise. There should be, then, some differences in the results from the diagrams and those deduced from the formulæ. But they approximate sufficiently to allow the conclusion that $\frac{\mathrm{T}\,c\,i}{\mathrm{T}\,m}$ ranges between 12 and 14 per cent, or a mean of 13 per cent, in which $\frac{\mathrm{T}\,r}{\mathrm{T}\,m}$ figures for seven per cent, and $\frac{\mathrm{T}\,p}{\mathrm{T}\,m}$ for six per cent.

Numbers in the Order of the Diagram.	Pressure in the cylinder before cut-off, H.	Normal pressure in condenser, p.	Admission into cylinder, $\frac{L}{E}$.	Duration of condensation. $\frac{n\,L}{L} = n$.	By Diagrams. Numbers proportional to $\frac{T\,m}{S}$, or area $a\,b\,c\,d\,h\,i$.	By Diagrams. $\frac{T\,r}{T\,m}$	By Diagrams. $\frac{T\,p}{T\,m}$	By Diagrams. $\frac{T\,ci}{T\,m}$	By Equation (8), $T\,ci = \frac{1}{3}\,S\,L\left(\frac{P-p}{1+r}\,n + 3\,p\right)$. $\frac{T\,m}{S} = H\,E\left(1 + l\,\frac{L}{E}\right)$	By Equation (8). $\frac{T\,r}{T\,m}$	By Equation (8). $\frac{T\,p}{T\,m}$	By Equation (8). $\frac{T\,ci}{T\,m}$	Modified Condenser, $T\,ci = \frac{1}{3}\,S\,L\left[\frac{P-p}{1+r} \times \frac{1}{2}\left(1 - \cos\frac{\Sigma'}{\Sigma}\right) + 3\,p\right]$ $V = z$, $\Sigma = 10\,\Sigma'$ $\mu = 2\,c\,m = .03$ k. $\frac{T\,r}{T\,m}$	Modified Condenser. $\frac{T\,p}{T\,m}$	Modified Condenser. $\frac{T\,ci}{T\,m}$
	kil.	kil.													
No. 1, Fig. 3......	3.09	.092	.31	.72	2.780	.082	.061	.143	2.081	.083	.044	.127	.017	.014	.031
No. 2, Fig. 4......	3.20	.076	.22	.78	2.482	.077	.064	.141	1.769	.077	.043	.120	.015	.017	.032
No. 3, Fig. 5......	2.84	.069	.29	.73	2.434	.071	.059	.130	1.848	.083	.037	.120	.016	.017	.033
No. 4, Fig. 6......	3.09	.088	.21	.88	2.324	.077	.067	.144	1.662	.083	.053	.136	.014	.018	.032
No. 5, Fig. 7......	2.58	.088	.30	.79	2.280	.071	.065	.136	1.904	.099	.046	.145	.014	.016	.030
No. 6, Fig. 8......	3.09	.076	.11	.94	1.702	.065	.077	.142	1.090	.064	.069	.133	.011	.028	.039
No. 7, Fig. 9......	3.09	.075	.15	.84	1.872	.062	.065	.127	1.315	.080	.056	.136	.004	.023	.027
No. 8, Fig. 10.....	3.09	.075	.085	.82	1.528	.065	.078	.143	.912	.047	.082	.129	.009	.033	.042
No. 9, Fig. 11.....	3.09	.070	.13	.80	1.850	.030	.063	.113	1.221	.061	.057	.118	.012	.024	.036
Mean..........	....	....	....	....	....	.069	.066	.135	.....	.075	.054	.129	.012	.021	.033

It will be seen that, in the actual condenser, $\frac{T\,c\,i}{T\,m}$ varies between .118 m. and .145 m., the mean being .130 m. This ratio, in the modified condenser, gives a mean of .033 m., being an economy of 6.5 per cent of developed power, not including the economy in the working of the air pump.

(To be continued.)

MALLEABLE CAST IRON.

Translated from "Le Génie Industriel."

For the production of this material most of the German founders use first fusion pig, free from sulphur and phosphorus, or Scotch pig. Styria also furnishes a suitable iron, which can be used only in the north of Germany, however, on account of the expense of transportation and high duties. On account of the competition of wrought iron, great cheapness is very essential to its sale.

The makers keep secret the brand or grade of iron which they employ, but it is well understood that the brands are not the same in different establishments. The iron is melted in plumbago crucibles, holding about 30 kilog. They are covered with porcelain lids, to keep out impurities and cinders which reduce the high heat requisite for the process. The fire, in which the crucibles are placed, is from .630 m. to .940 m. square, and is surrounded with bricks of porcelain earth. The use of blast is not advantageous, since the economy of time is offset by a greater consumption of coke. The natural draught of the chimney is sufficient when the furnace is properly constructed. As we have said, an essential condition of success is a high heat at the moment of pouring. Practice enables the founder to estimate the heat of the furnace, and he recognizes the precise moment by plunging a bar of red hot iron into the crucible, from which, upon being withdrawn, the metal flies off in sparks. The crucibles are raised with tongs, with curved jaws, and the pouring is done with all possible promptitude—the surface being first cleaned.

By cementation the casting acquires the properties of wrought iron, having some analogy to steel. The operation consists in subjecting the castings to a prolonged red heat, in a bath of pulverized red hematite. They are arranged in boxes of cast iron called muffles. It would seem that the cylindrical form ought to be most advantageous for the boxes, but practically they are simply square, and with covers which should keep out entirely the least access of air.

In arranging the castings in the boxes they are placed in layers alternately with layers of hematite. The cementing furnace is very simple. The grate is in front, and the draft of the chimney carries the hot air around the boxes. The heat should be conducted with care, starting rather vigorously, in order to reach quickly the desired temperature; then supplying the furnace at regular intervals. The cementation lasts three, four and five days, according to the size of the pieces. A charge is about 350 to 450 kilog. of castings. In arranging the charges large pieces should not be mingled with small, and those muffles containing the larger pieces should be placed in the furnace first. On the other hand the smaller objects are placed on the sole of the furnace. Without these precautions many pieces may be burned, or badly decarburized—the latter becoming something intermediate between iron and steel. When the operation is deemed complete, the fire is allowed to fall, but the furnace is not uncharged until it has gradually cooled. Practice plays an important part in the management of the firing, as the temperature can be judged of only after prolonged experience. Next to the fuel, the greatest expense is the cementing boxes, which are often serviceable only for a single operation.

THE PENNSYLVANIA STEEL WORKS.—These works are producing eight heats of five tons each in one "turn" of twelve hours. This is remarkably fast working, and proves the excellence of the machinery and of the management. The entire eight heats of iron are melted in one charge of the cupola, as improved by Mr. Pearse.

AMERICAN RAILWAYS.

AN ENGLISH VIEW OF THEIR MERITS AND DEFECTS.

From the correspondence of "Engineering."

In the mechanical construction of American rolling stock the bogie plays a most conspicuous part, and is the chief feature of difference between our own practice and that of American engineers. In America its adoption is universal, whilst in this country, in actual practice, it is very little known. There must, of course, be some substantial reason for so great a difference between the practice of two countries so intimately connected.

In the first place, then, the permanent way in America is generally understood to be inferior to our own, and on this point I think very little doubt can exist. The section of rail is usually considerably lighter than with us, and is out of all proportion to the loads it has to carry. The roads are scantily ballasted, and the use of ballast at all is the exception, and not the rule. Much has also been said about the inferior quality of the rails sent to America, but I would venture to say the rails are "more sinned against than sinning," as I shall presently show.

Those who have not had an opportunity of examining the permanent way can form no idea of the rough character it presents. The rails are laminated, bent, crushed, and out of line to an extent entirely unknown in this country. The "fishing" of the joints is also done in a very inferior manner, and there are thousands of miles laid without the joints being fished at all. On one line, where I was detained owing to a goods train being off the track—the result of a broken rail—I took the opportunity of noting the inequalities of the road, and measured the distances the rails had parted asunder at some of the joints; I found in many places the gaps to vary from 1 in. to 3½ in., and the ends of some of the rails thus separated were off the sleepers altogether. The breaking of the rail in question, therefore, ceased to be a matter of surprise. In winter the ground is frozen, for months together, almost as hard as granite, and, practically, during this time no repairs can be done to the road; to make the matter still worse, in freezing it often happens that one rail is elevated 6 in. or 7 in. above the level of the other. These "frost-blisters," so called, are of frequent occurrence, and the unevenness of the line is a source of great trouble and danger.

Some idea may be formed from this of the difference between the American permanent way and our own. It is to such roads as I have described that American engineers have had to adapt their rolling stock, and for them the bogie is an *absolute necessity*, as it enables a carriage to pass over such roads as I have described with less oscillation, vibration, or jolting than is experienced in the railway carriages in this country.

It is only justice, however, to say here that, with increased capital and other favorable circumstances, many of the American lines are being gradually reconstructed and the permanent way made generally equal, and, in some respects, superior to our own; rails of heavier and better sections are being laid down, and steel rails, with steel fish-plates, of greater length than ours, are being largely introduced.

It may, therefore, be worth while to consider if the Americans can construct carriages to pass smoothly over rough roads, whether it be not possible for English engineers to construct stock which, at all events, will run with some degree of comfort over lines which are incomparably superior. The chief difference between the two is, that in the American arrangement, all, or at least the greatest part, of the motion arising from the irregularities of the road is absorbed by the bogie, and not transmitted to the body of the carriage, whilst with us every unevenness in the road is at once communicated to the body of the carriage, the result being that our carriages oscillate at times to a frightful extent, which not only unpleasantly affects the passengers, but is a source of considerable extra expense to the railway companies, for the carriages require to be much heavier than would otherwise be necessary, to withstand the shocks caused by the whole weight of the carriage being thrown violently from one side to the other; the flange friction and also the friction on the ends of the journals is much increased, and the damage to the tyres and permanent way consequently much greater.

It is often a matter of wonder why omnibuses traveling over roads which for evenness bear no comparison to a railway should be so much lighter in proportion to the load they carry. Put hornplates on an omnibus, and you will soon shake it to pieces, and no passenger would ride in it a second time. In an omnibus, however, the irregularities of the road are absorbed by the springs, and not transmitted to the body of the vehicle, and why should not the same principle be carried out in railway practice? Some time ago Mr. Attock, the carriage superintendent of the Great Eastern Railway, successfully interposed india-rubber blocks between the body of the carriage and the frame, in order to prevent the noise being transmitted; the arrangement having also other advantages. The comfort to passengers was found to be so great from this simple introduction that most of our railway companies immediately adopted it, and few carriages are now constructed without the india-rubber blocks. If this principle were carried a little further it would be comparatively easy, not only to prevent the transmission of sound, but also of violent motion arising from inequalities of the road, and the principle embodied in the swing bogie of America would accomplish this, and might easily be adapted to the existing rolling stock.

Having said so much in reference to the principle and utility of the bogie, I may proceed to another distinctive feature in American rolling stock—the chilled cast-iron wheel. The Americans are perfectly familiar with the construction of our carriages, wagons, and locomotives, and the best English examples have been tried on their lines of railway. I saw in the shops of several railway companies numbers of English-made wheels, both wrought iron and wood; some of these had been tried, but very soon broke up, and were frequently the cause of accidents.

However anxious American engineers are to adopt the best arrangements of their own or other countries, we have not been able to offer them wheels at all approaching in strength, durability, and cheapness to their cast-iron chilled wheels.

It was shown both in a recent paper* and during the discussion which followed upon it, how much stronger, cheaper, lighter, and enduring these wheels as manufactured in America (and also on the Continent, where they are largely used) are to our own. Since the Americans have paid us the compliment of trying varieties of wheels manufactured in this country, we might return the compliment, and see how far their wheels would be valuable to us here. One of our most enterprising locomotive super-

*Read before the Institute of Civil Engineers.

intendents, Mr. William Adams, has already made an experiment with them, and in reply to an inquiry as to the result, says, that after running them for a considerable length of time under the bogie of one of his heavy engines, he could see no traces of wear at all, and that the surface in contact with the rail was simply polished.

The American wheels are made from the best cold blast charcoal iron, the strength of which is exceedingly great, as may be judged from their test bars standing a tensile strain of 18 to 21 tons per square inch of section; and not only is the tensile strength great, but their tenacity is equally striking. In breaking the pigs I have seen them bend to a very visible extent before separating. Scotch iron in one or two instances has been attempted, mixed with superior American iron, but without success, and all such admixtures are regarded with extreme suspicion, and are only attempted by inexperienced or unprincipled manufacturers. It is worthy of remark that even among the better class of charcoal irons there is almost as much difficulty in obtaining suitable material (with the requisite chilling and other properties) for these wheels, as there is in selecting suitable material for good Bessemer steel. In America, out of a considerable number of generally excellent irons there are not more than half a dozen which have obtained a special reputation for this class of work, among them the Salisbury, the Richmond, and more recently, and with remarkable success, the Acadian charcoal iron, which, notwithstanding the very high duty of nearly £2 per ton, has been imported from Nova Scotia for the manufacture of chilled wheels by Messrs. Whitney and Sons, of Philadelphia.

In Germany, too, where these wheels are greatly in vogue, and where their manufacture has been conducted with special skill, the range of selection of really suitable irons is comparatively small. The cost of such iron ranges from £6 10s. to £7 10s., or even more, per ton in the States, and the price of wheels 2 ft. 9 in. diameter, weighing from 400 to 550 lb. ranges from £2 15s. to £3 7s. 6d. per wheel or an average of about £14 to £14 10s. per ton. The distances travelled by these wheels have been variously stated, but the average may be safely taken as from 100,000 to 150,000 miles. I may just mention that the wheels are not keyed on, but simply forced on by hydraulic pressure, varying from 20 to 30 tons. There is nothing peculiar about the axles employed, but the axle-box is simple and convenient in construction. On many lines the bearing is formed by running white metal into a brass frame, which is found to be much more economical than brass alone. The distance these bearings will run is from 50,000 to 55,000 miles, and afterwards they are again lined up. The journals are lubricated with crude surface rock oil from the wells of Pennsylvania, the cost of which is only 6d. per gallon; in England we pay from 3s. to 4s. 6d. per gallon.

It is very pleasing to note the efforts made by all the railway companies in America to secure the greatest amount of comfort to the passengers. The subject of ventilation has occupied considerable attention, and ingenious contrivances for effecting this most desirable object are very numerous and interesting. It is a very easy matter by opening a window to admit a rush of air into a compartment, as many of us know to our cost, and it is very uncomfortable to be stifled by having the windows closed altogether; between the two—in this country—we have very little alternative; there are certainly what are termed ventilators over the doors, but they are all but useless, not being constructed on any correct principle for the proper circulation of air.

Now, the Americans have a very simple plan for exhausting or drawing the impure atmosphere out of their carriages, which is the principal difficulty experienced in all attempts at ventilation. On one occasion, whilst traveling in a sleeping car, I felt a strong inclination to smoke a cigar; I asked the attendant if it were permitted, and was informed that such a thing was never allowed; but, seeing that I was an Englishman—and with that desire which, I must say, evinces itself at every turn to show attention to our countrymen—he said: "Though it is not allowed, Sir, I will fix you up so that you can smoke your cigar and no one shall know. I was curious to see how this was to be done, as there were passengers sleeping on every side who would certainly have complained had they perceived anything so unusual. ' Presently he appeared with a small flat board about 7 in. wide and 13 or 14 in. long. "This, Sir, is the ventilator, which I shall put in the window, and you can then smoke as much as you like." He then opened the window, and inserted the board so that it projected at right angles to the carriage-body, immediately causing a strong outward current of air which took away the smoke. The principle of it is easily seen: the board causes a rush of air in front of the window, to the distance it is projected, and a vacuum is thus created on the other side of the ventilator, and the air exhausted from the carriage. With this simple contrivance—and the same principle is carried out in various ways by the Americans—for exhausting the foul air, and by admitting the pure through a considerable area of fine wire-gauze, either in single sheet or a double, placed so as to leave a space between the two—instead of allowing the air, as is the usual practice here, to rush through unchecked openings injudiciously placed, causing dangerous draughts—we should have a very efficient method of ventilation.

I would next make a few remarks on their locomotives. It has been said that the difference between between English and American locomotives is in outward appearance only: this may be so to a great extent, but I think there are points of detail (and points of detail are sometimes very important) which are worthy of note and consideration. The first glance at an American locomotive gives you the impression of an old Bury engine with a bogie in front and a great deal of Birmingham finish, and one is inclined to imagine that American engineers cannot have seen English locomotives, but this idea is soon dispelled when they are examined in detail or their performances witnessed. The curves on some of their main lines are very severe: as an example, those on the Pennsylvania Central above Altoona are set out to a radius of 600 ft., not for short distances only, but in long lengths of continuous curves. The heavy traffic is worked over this section of the line by means of six-wheeled coupled engines, which in passing round the curves have comparatively no flange friction at all; the bogies of these engines have a swing motion similar to that of the carriages, which leaves the engine, to a great extent, free in front; the bogie wheels are made to correct guage, and, in order to prevent grinding or flange friction, the leading and centre driving wheels are virtually without flanges, the leading wheel having no flange and the middle wheels being very slack in guage, whilst the trailing wheels fit the gauge exactly. From this it will be apparent that there are no binding points throughout the whole wheel base. The tyres of the two middle wheels are made much broader to allow the necessary lateral travel. Four-wheeled coupled engines are also sometimes made without any flanges on the driving wheels.

The framing is made of square bar iron, well put together; plate-framing has been tried and abandoned. The slide valves are horizontal and worked by means a rocking shaft; direct-acting valves have been tried, but given up, and all engines with such valve arrangements sent from this country have been altered.

Instead of the balance weight to the link motion, a simple arrangement of coil spring has been substituted, which has a neat appearance and enables the reversing lever to work more freely.

A "Ramsbottom" arrangement of screw-reversing gear has on some lines been adopted in combination with the reversing lever, so that either one or the other can be used. The eccentric straps and sheaves are of cast iron, neither brass nor white metal being used. They wear much better, are much cheaper, and give no trouble. The smoke-box is simply a continuation of the boiler plates, and the smoke-box door is of cast-iron. This makes a strong, substantial arrangement, and at the same time cheap and easy of construction.

Steel boilers are becoming very general, and were to be found in the locomotive shops of all the railways I visited, and steel fire-boxes were also very largely employed. American engineers have no hesitation on this subject, and could they obtain good steel plates as cheaply as we can in this country, the use of iron plates would soon be abandoned. The fire-boxes are only $\frac{1}{4}$ in. thick, and some of the locomotive superintendents informed me that, were it not for the difficulty of the stays, they would have them still thinner. Thin plates are advantageous in two ways; steam is generated more rapidly and economically, and they admit of easy expansion.

Steel fire-boxes have broken in this country, but this, I believe, was owing in a great measure to the thickness of the plates. Whilst we are hesitating in this country about the use of steel boilers, the Americans have passed through the field of experiment, and are now largely using them. I saw a steel boiler tested at Pittsburg; the plates were $\frac{1}{4}$ in. thick; the boiler was 38 in. diameter and 4 ft. long, with flat ends stayed longitudinally. Some of these stays gave way with a pressure of 780 lb. on the square inch, and one end of the boiler was blown out, the thickness of the plates being much greater than in the barrel. Before bursting, the barrel stretched 4 in. in circumference beyond its original dimensions.

The weight on the driving wheels of the 4-wheeled coupled engines is from 8 to 12 tons, being very excessive for the prevailing light sections of rails.

We are astonished when accounts reach us of the number of rails broken in America, but to any one who has been over there and investigated the subject, it is a matter of surprise that the number is not greater. The weight of the rails, generally, is from 56 to 60 lb. when new, but, but after several years' hard wear this will be reduced to about from 48 to 52 lb. The rails are so crushed in many places as to reduce the section to the web and bottom only. That such rails should break with engines of 30 to 35 tons, with 12 tons on an axle, is certainly not surprising.

Though the engine plays a destructive part in the wear and tear of the rails, the wagon stock is equally, if not more, destructive. The worst feature in this department is the inefficiency of the springs under the wagons. India-rubber is employed to a great extent, and thousands of wagons are provided with nothing but small blocks of rubber of such insignificant dimensions as virtually to render the wagons without springs at all; and in winter time, especially, when the ground is frozen as hard as stone, and when the greatest amount of elasticity in the stock is required, these small blocks of rubber are practically of no value, and wagons weighing, when loaded, from 20 to 25 tons, are running dead over the frozen track. Some of the wagons, provided with steel springs, are very little better. I measured a number of the springs and found them actually not to exceed 12 in. between the bearing points, and far too stiff and rigid to afford any relief to the superincumbent load. I have seen a number of anxious American letters on the subject of rails sent out from this country, both iron and steel; but of what extraordinary material must a rail be made to stand such punishment as I have referred to, not to mention other causes which I will not now attempt to discuss.

As a brief comparison of the relative amounts of dead weight to the load carried would, perhaps, be interesting to your readers, I may mention that the American carriages generally carry about 70 passengers each. The weight of the carriages, formerly, was from 12 to 15 tons, but those recently constructed are no less than 15 to 17 tons.

The "drawing-room cars" (so called from a fear of making any avowed distinction of class, such as first, second, and third) are still heavier, while the weight of the sleeping cars are from 20 to 35 tons. The greatest difference, however, between the practice of the two countries lies in the dead weight to the paying load in their goods traffic. The largest proportion of their freight cars are covered goods wagons, measuring from 28 to 30 ft. long and about 8 ft. 6 in. wide, with a bogie at each end. The total weight of these wagons is from 9 to 11 tons, and the load they are required to carry is from 9 to 12 tons, or, practically, an equal weight of dead load to the paying weight carried.

So miscellaneous are the weights and dimensions of our English wagons that it is difficult to classify them, but taking a fair average we may safely assume that as regards dead weight we have an advantage of at least 30 per cent. in our favor.

FOUNDRY ECONOMY.

In a late lecture on "Applied Mechanics," before the Society of Arts, Mr. John Anderson, C. E., Superintendent of Machinery to the War Department, after familiarly describing the distinctive properties of cast and wrought iron and steel, proceeded to speak of the molecular structure of metals. All metals, he said, are crystalline, but the crystallization is better observed in some metals than in others. In cast iron, especially, it is very apparent. The crystallization of cast iron is governed by a natural law. This law was first pointed out, to the best of his belief, a few years since, by Mr. Mallet, and is this: When cast iron is in a liquid state—when the molecules have sufficient heat amongst them to give liquidity—the direction of crystallization is determined by the lines into space which the heat takes. When this law was first started it was received with skepticism, but ever since the law had been pointed out, he (the lecturer) had never observed in any piece of broken metal an example to the contrary. If we introduce into castings irregularity of figure, or anything which creates currents outwards in various directions, then we get wrong; we introduce lines of weakness. According to this law, guns up to this time have always been made wrong.

The Americans are acting upon this law in everything they are doing, and that gun of theirs which some time back came to this country, almost like a soda-water bottle in shape, was constructed in strict accordance with this law, and, therefore, possessed the utmost strength attainable with the same weight of metal. The molecular appearance of cast iron depends on the rate at which the heat is hastened out of the casting.

As to the goodness of cast iron, goodness for small castings is not goodness for an hydraulic cylinder; goodness for an hydraulic cylinder is not goodness for a gun. Density is a quality good for both the latter, but we don't want ductility for an hydraulic cylinder, but for a gun it is required; for the hydraulic cylinder we want very great density. As a rule, the hardness of cast iron or cast steel depends upon three things: 1, on the quantity of carbon which the mass contains; 2, on the heat to which it was raised before carrying the heat out of it; and 3, on the rate at which that heat is hastened out it. All these conditions go to determine the character which cast iron or cast steel assumes. In casting iron in moulds, where hardness is wanted, some method is adopted so as to carry the heat out rapidly, and where softness is required, means are taken to allow the heat to go out slowly, and it does not much matter what the method is so long as it is effectual. The hardness of steel depends upon the quantity of carbon which it contains, and on the rate at which the heat has been carried out of it. After alluding at some length to the founder's art, the lecturer proceeded to speak of the casting of a fly-wheel, pointing out that the only thing which would preserve such a casting intact whilst cooling was to take care that every part should cool at the same rate. The arms, being least in substance, would naturally cool first, but they must be kept hot by covering them with fire or by any other convenient means. If we require a particularly good casting, it must be cooled slowly.

Many of the difficulties of the caster would be got rid of if we could prevent the formation of the gas within the mould. The Americans are very much more careful in this respect than we are, and this is the explanation of their cast-iron guns standing so well. Mr. Babbitt uses old firebricks, which after, say ten years' service, have not changed color; any firebricks at all discolored he rejects. He grinds these to a powder, and thus gets a perfectly pure and refractory material for his molds, using pipeclay, the best material for the purpose, to render it adhesive. The mold is first made red-hot, and this red-hot mold then receives the metal. Not a particle of gas is generated by the mold. Another American founder, Mr. Hains, uses kaolin, which he obtains from England (Devonshire), and treats it in a similar way to that in which Mr. Babbitt treats his powdered firebricks and pipeclay. To show the earnestness of our American competitors—and we shall have them as competitors—they resort to the method of of taking the heat out of the castings in the way which would be least injurious to them. They try to establish the conditions of a built-up gun in a cast-iron one, to have every atom of the gun under tension. We English, as a people, must pay the same attention to natural laws as the Americans and the French are doing.

ELECTRICITY AS A MOTIVE POWER.

From the "American Journal of Mining."

Some time ago we touched lightly on this subject in an article entitled: "Electricity and Steam." We pointed out how much more expensive the former is than the latter, for the simple reason that the source of the first power is zinc, a product of art, and of the latter coal, a product of nature, also that if we add to the difference in price, the difference in the chemical equivalent which makes six pounds of coal as effective as 64 pounds of zinc, we obtain as a result that zinc will be more than 100 times more expensive than coal. But the difference in coal is practically even more than this. For the oxidation of the zinc acids are needed, also products of art, and for the oxidation of the coal or carbon common air, a product of nature, literally costing nothing at all. Now, as there is no reason whatever to suppose that electric engines are more perfect than our best steam engines, with all the modern improvements, for the reason that our experience in manufacturing electric engines is very small, and in the steam engines very great, we may confidently assert that the continual running of an electric engine for practical purposes would at the present day cost a thousand times more than the amount incurred by a steam engine, so that the amount of power obtained from the first, at a cost of ten dollars, would be obtained from the last at a cost of only one cent.

Notwithstanding this, we see from time to time inventors—who, by the way, are often apt to forget what should be the final question in regard to all enterprises ; will it pay?—basing their experiments upon our present highly expensive sources of electricity, and contriving new combinations of currents and magnets, hoping by some scientific hocus-pocus combination to obtain a miraculous effect. Some twenty years ago there was a large electric engine mania among inventors, just as there is at the present day in regard to ice and cooling machines. Scarcely a month or even a week passed that some new combination of electro-magnets of peculiar form, was not exhibited, usually patented, as each inventor supposed his combination to possess such superior advantages to outdo all competitors in that line ; often, however, the peculiarity insisted upon by the inventor, as a great advantage, turned out to be a defect, and the machine would perhaps scarcely go at all. We remember in this connection some machines remarkable for the total want of theoretical knowledge shown by the inventors. One of them had enormously elongated pole ends at the electro-magnets, the inventor erroneously supposing that their large surfaces of iron would exert great attraction, and not knowing that such elongated poles acted like attached keepers, absorbing almost all the attractive power developed by the coils; however, the machine was made on a large scale, at the expense of several thousand dollars, and when finished, showed much less power than the simple machine—in fact, it scarcely moved at all.

In order that the uninitiated reader may fully understand all this, and what is to follow, it is only necessary to state, that when a piece of soft iron is surrounded by a coil of insulated copper wire, and an electric current passed through this wire, the iron will become a strong magnet, and lose its magnetism at once when the current is interrupted. All that is necessary, therefore, to cause intermittent attractions is an intermittent contact with the electric battery, and these attractions will cause to-and-fro motions, which by means of a crank may be changed into rotary motion ; or the intermittent magnets may be placed on the circumference of a wheel, and attract similar other magnets, or as many pieces of iron ; the contacts with the battery being made and broken, by means of some automatic arrangment worked by the motion of the machine itself.

Numbers of such contrivances have been made, and may be seen in every physical cabinet; but in fact they are in a physical point of view mere illustrations, of the properties of electro-magnets. When considered in a mechanical point of view, they are mere toys; and in reality there never was a machine of this kind yet constructed, even on a large scale, which was in reality more than a toy.

But not only these so-called electro-magnets will attract one another, or attract iron, but the currents themselves will attract each other when running in the same direction, and repel one another when running in opposite directions.

This was discovered by Ampere in France, some 40 years ago, and has given rise to a new branch of physics, called electro-dynamics. It was first applied to moving machines by Mr. Vergnes, from France, living in New York City, who had made the study of electricity a speciality, and, in the ambition of his inventive genius, again overlooking the great ultimate question as to cost, constructed the largest electric motive engine perhaps ever made. It was repeatedly on exhibition, and was shown in the Crystal Palace, New York, at the world's fair in 1852. It worked admirably, and with seemingly considerable power, which, however, never was measured. It is a curious fact that in any machine of this kind the inventors always oppose most strenuously any such measurement. The battery used was enormous, many hundreds of cups and carboys of acids being in operation, so that the expense must have been ruinous.

In this machine Mr. Vergnes had wisely combined the attraction of the iron of the electro-magnets, with the attraction and repulsion of the currents themselves, according to Ampere's discovery; for the reason that the attraction of the currents, or rather of the wires conducting the currents, is comparatively very weak, so that quite a strong battery is required to demonstrate this attraction at all, while the attraction of electro-magnets will manifest itself most strikingly with a battery of one-hundredth part of the size of that required to cause the mere currents to attract each other. This fact is well known to every one who has ever experimented with voltaic batteries, currents, etc.

Taking all this into consideration, we cannot disguise our great surprise, that the newspapers should this week contain a glowing description of a so-called newly-invented electro-motive engine of M. Griel, a French military officer, based on the action of currents on currents; asserting that all inventors thus far had confined themselves to the use of electro-magnets, and that here for the first time the laws of dynamical electricity have been brought into play.

Now the fact is, that if not in all, at least in most philosophical collections, there are pieces of apparatus, in which, on a small scale, this principle is illustrated, and Vergnes, mentioned before, has, with many others, put this principle in practice, but found that when discarding the use of electro-magnets entirely, the most advantageous effects were lost. No doubt Mr. Griel's machine would be stronger if advantage were taken of the powerful magnetic action acquired by soft iron under the influence of electric currents, in place of confining the power to the comparatively weak attraction and repulsion produced on the pure electro-dynamic principle.

The battery described for driving this machine is identical with Bunsen's, namely amalgamated zinc, diluted sulphuric acid, porous cups, strong nitric acid and coke. It appears to be of enormous dimensions, and of course correspondingly enormous expense.

The most curious thing, however, is the calculation of Mr. Griel, by which he attempts to prove that when using steam the expense increases in direct ratio of the horse-power obtained, and that when using his machine, it will only increase somewhat as the cube-root of the power obtained, as shown in the following table given by him:

Horse-power obtained.	Expense— Steam.	Electricity.
2	..	..
16	$8	$2
64	16	3
250	125	5
2,000	1,000	10

and conceding that for two horse power electricity costs 25 times more than steam, when using 250 horse power it becomes equal, and for 2,000 horse power it will be four times as cheap.

Now, the fact is that electricity, in the way he obtains it, is not only 25 times, but 1,000 times more expensive than steam, and that the calculation of relative reduction of expense for greater power is entirely false and erroneous.

To crown all, he states that he can apply his machine to railroads, and by means of an electro-magnet of his invention (most wonderful) cause the electricity to wash from the wheels of the machine upon the rails, and proposes to ascend any grade with the greatest facility.

It is now several years since M. Nickles, of France, who, we regret to say is recently deceased, proposed to accomplish the same thing by similar means, and about six years ago the same idea was again revived by an American inventor, who tried to prevent the slipping of the driving wheels on the rails by exactly this plan, making that part of the wheel which touched the rail a temporary electro-magnet. It was tried, at great and prolonged labor and expense, but given up as totally impracticable. One French inventor goes even further, and appears to have the intention of also driving the cars forward by his machine.

It is matter for surprise, that the editors and reporters of our public press, otherwise so well informed in matters political, religious and otherwise, are so little posted on scientific matters, as continually to be deceived by the pretentious claims of inventors. True men of science too often meet with cold contempt, while charlatans and deluded enthusiasts are received with almost superstitious credulity.

TORPEDOES.

From the "Pall Mall Gazette."

The strides which have been made within the last ten or fifteen years in the application of science to warlike purposes are nowhere more marked than in the use of electricity as a military agent. It is applied to military telegraphy, to signalling and reconnoitering purposes, to the determination of the ballastic powers of guns, to many naval uses, such as signalling and the simultaneous discharge of broadsides; to various experimental purposes, including the proof of guns; last, but not least, to the explosion of land and submarine mines. The history of the subject and its most recent phases were treated a few nights ago at the Royal Institution by the gentleman to whom above all others we are indebted for the development of this special branch of application of the science. The interest of Professor Abel's excellent lecture centered, however, in his account of what has been done in this country towards the establishment of a system of torpedo defence. It was the first authoritative utterance on the subject which has yet been heard, and the immense importance of the question, combined with the secrecy in which it has thus far been shrouded, suggest the desirability of taking advantage of the occasion to say a few words about it.

Torpedoes form the most important class of those marine obstructions which are now generally admitted to be indispensable to effective coast and river defense. They are the active as contradistinguished from the passive obstructions. The importance of obstructing roadsteads, rivers, and harbors —of placing, so to speak, an outer belt or circle of defenses, external to the chain of forts, and even where no forts existed—has long been understood. It would be difficult to assign a date to the first employment of rude appliances of some sort for effecting this object; even submarine mines, which are a more advanced type of defense than piles and artificial barriers and fire ships, were used as far back as the sixteenth century, when they were employed, in 1583, by the Duke of Parma at the siege of Antwerp. The English used them against the French ships off Rochelle in 1628, and during the long lapse of years between 1628 and 1854, the subject was never wholly lost sight of. Always there were men with contrivances more or less ingenious, more or less impracticable, ready when the opportunity offered to revolutionize with their torpedoes the art of coast defense. But science was during that time in its infancy. The torpedoes in occasional use prior to 1854 were rude and imperfect, and the development of the subject was cramped by the absence of sufficient knowledge or study to enable electricity to be usefully employed as the agent of ignition. Thus the first torpedoes were of the mechanically exploding class. All sorts of plans were devised and all sorts of agents were employed—percussive, frictional, chemical, and clockwork. It is evident, however, that mechanical torpedoes can never be altogether satisfactory. They are open to one salient objection, viz, that once in position and ready for action they close the navigation alike to friend and foe, and there is always a certain amount of danger attending their manipulation. These evils have been attempted to be mitigated by various safety arrangements, so-called, the application or the removal of which, however, as often as not proves so dangerous as to furnish a formidable objection to their employment. Thus, when the Russians employed, for the defense of Cronstadt, mechanical torpedoes with a safety arrangement, which should have been removed at the last moment, they generally, for very good reasons of their own, neglected to remove it, and the torpedoes in consequence proved absolutely innocuous. Again, the removal of the torpedo is frequently a source of danger, and several instances have recently occurred in America of loss of life under these circumstances. Nevertheless, mechanical torpedoes will probably always possess a certain value, as on remote foreign stations, where the means of defense have to be extemporized on an emergency, or for what are called "drifting" or movable torpedoes. This abortive employment of torpedoes in the Russian war of 1854–5 marks the first systematic use of the instrument in European warfare on a large scale. In 1855 electrical torpedoes were attempted; and by 1859 the Austrian Government had succeeded, with the assistance of Baron von Ebner, in perfecting a sufficiently simple and practical system of electrical torpedo defense, which was applied, although without results, at Venice. Until lately the Austrians may be said to have headed the science, and their exhibition of a complete system of torpedo defense formed an interesting part of the display at Paris in 1867. No really important illustration of the great value of torpedoes was furnished until the late American war, when these agents were employed in many forms, chiefly by the Confederates, and with remarkable results. No less than twenty-five vessels of the Federal navy were destroyed and nine others were injured by the explosion of torpedoes; and thus an impetus was given to the subject, similar to that which breech-loading derived from the Bohemian campaign of 1866. If any one wishes to study the detailed application of torpedoes during the American war, he can hardly do better than consult Von Scheliha's *Treatise on Coast Defense*, where also he will find the following important deductions from the experience obtained during this contest: "No forts now built can keep out a large fleet unless the channel is obstructed." "No fleet can force a passage if kept under fire by obstructions." "*In no single instance did a naval attack succeed when the channel had been obstructed, and in no single instance did it fail when the channel had remained open.*"

The attention of our Government was directed to the subject towards the close of 1863, when a committee was appointed, at the suggestion of Colonel Jervois, R.E., for the thorough practical investigation of the whole question of marine obstructive defense. From that time until the latter part of last year, the committee was actively engaged in an experimental inquiry, and the result has been the compilation of a report which is likely to prove the most complete and exhaustive treatise on the subject yet produced. Hitherto the report has been treated as confidential, and it is, no doubt, desirable that the details of the committee's recommendations should remain secret. But no objection can be urged against the production of so much of the report as would inform the public in general terms of the successful termination of the committee's labors, and of the broad results purchased at a not inconsiderable expenditure of time and money. It would be satisfactory to have some definite and authoritative assurance that the national interests have not been neglected in this vital question of defense, as well as an assurance that the recommendations of the committee will be duly and practically accepted. We observe that the very inadequate sum of £2,000 has been taken in this year's estimates for the provision of torpedo equipments, and for further inquiry and instruction. The gunnery ships of Portsmouth and Plymouth, and the Engineer's School at Chatham, now regularly include the use and management of torpedoes in their course of instruction.

To return to the torpedoes themselves. We have stated that mechanical torpedoes, however occasionally useful, are necessarily imperfect and, to a great extent, dangerous appliances. The advantages which attach to the application of electricity to the explosion of torpedoes are great and manifest. Torpedoes of this class may be placed in position with absolute safety to the operators; they may be rendered active or passive at any moment, as desired; they thus do not close to friendly vessels the channels which they guard; they can be stationed at any depth beneath the surface; their action is generally very much more certain than that of a mechanical torpedo; and they can be removed with perfect safety. As in the case of torpedoes of the mechanical class, the arrangements for securing action may be almost infinitely varied. Frictional, voltaic, dynamo-electric or magnetic electricity may be employed, each possessing specific advantages or objections; and the circuit which determines the explosion may either be completed by the contact of a passing vessel or at the right moment by an operator on shore. The latter system, which admits of many modifications, is probably the more simple; but it imposes the necessity for great vigilance, promptness, experience and harmonious co-operation on the part of the operators. It is also inapplicable at night or in thick weather, and might even fail under the dense smoke of a hot action. A more generally efficient plan is that of contact-exploding torpedoes, which are either exploded by their collision with a ship, or by the vessel striking a circuit-closing arrangement moored near the surface of the water, whereupon either the torpedo, moored at some depth beneath, is instantly exploded, or a signal is furnished to a station on shore, which indicates to an operator the particular torpedo to be fired, and when to fire it. It is essential in this arrangement to adopt a plan which, while sensitive to the passage of a vessel, shall not be disturbed by the simple action of the waves. These conditions include the necessity for simplicity of mechanism and a combination of sufficient but not excessive delicacy of action, with permanence during long immersion; but the problem, though difficult, is not insoluble, and one or two plans have been suggested which appear to satisfy the required ends. It seems to have been established that voltaic electricity is, of all the means available for the purpose, the one which presents the greatest advantages. And the substitution for the old platinum wire fuze, of the Abel fuze, in which the electric spark is generated by the interrupted passage of the current through a priming material of subsulphide of copper, subphosphide of copper, and chlorate of potassa, permits of the use of electric batteries which were before inapplicable, and of the explosion of torpedoes with perfect certainty at distances before unattainable. Indeed, the introduction of this fuze has rendered possible the development of torpedo science which has now been attained. The batteries may be of the simplest character, and a very efficient one can be readily extemporized with a piece of hard timber, a little zinc and copper sheet, an old blanket, some vinegar and common salt. A battery of this sort, weighing only 25 lbs. and about $7\frac{1}{2}$ in. square, will remain in good action for at least twenty-four hours, and can be easily cleaned and recharged. Such a battery, from its small size, weight, and great simplicity, is especially well adapted for boat operations.

The explosive agent to be employed in

torpedoes may be gunpowder, nitro-glycerine, or gun-cotton. Of these, gun-cotton is on many accounts preferred; and since the recent discoveries as to the susceptibility of gun-cotton to explosion by concussive effect, and the great resulting increase of power, its normal advantages have become more decided. There still remain a vast number of points, such as the nature of case or envelope to be employed; its thickness; the depth to which the torpedo should be sunk; the positions in which it should be fixed; the proximity of one torpedo to another; the the size, form, &c. The bare enumeration of these points will suffice to indicate that the subject is one which admits of an immense deal of working out, and will, perhaps, account for the length of time occupied in its investigation.

As to the practical value of torpedoes we have furnished some illustrations. But, in truth, it is unnecessary to multiply illustrations, for the value of these instruments may almost be regarded as self-evident. There are two points in every ship absolutely unprotected—the deck and the bottom. Of these the torpedo attacks one—the bottom. And it is a question if any ship can ever be made so strong as to resist the effect of a powerful submarine mine exploding directly under it. The use of torpedoes is not limited to serving as auxiliaries to forts, or as a means of keeping vessels under the fire of batteries. They are useful also on their own account, as a means of defending positions independently on a coast or in small channels and rivers which are quite unprovided with defensive works. Their invisibility forms another element of their importance, to which we may add their comparatively small cost and ready applicability to almost all positions. But it is necessary to guard against the impression that torpedoes are destined to supersede other and more old established means of defense, as ships and forts and guns. Invaluable as auxiliaries, and even as independent means of defense, their value is limited by two considerations. In the first place, the sphere of action of a torpedo is small; as compared with that of a fort or ship, exceedingly small; and an attacking vessel is safe as long as it contrives or chances to keep outside that area of destructive effect. In the second place, no torpedo can act more than once, and when it has exploded, the area of water which it guarded becomes defenseless. But with these limitations, their value can hardly be over-estimated; and it is satisfactory to know that the subject has been thoroughly and practically considered, and that we possess on paper at any rate a scheme for their use so complete as to relieve us from all anxiety on this score. It would, however, be more satisfactory still to know something definite as to the recommendations of the committee, and we hope that some member will think proper to ask in the House for such portions of the report as can be discreetly made public.

THE STABILITY OF FLOATING DOCKS.

From a paper on the Iron Floating Dock of Carthagena, its proportions and relative stability, read by George B. Rennie, M.I.C.E., before the Institution of Naval Architects.

The form of this dock may be briefly described as an oblong rectangular box or trough, without a top or ends, the walls and bottoms of which are hollow, and divided into several independent chambers. The vessel to be docked is placed between the side walls, and is raised completely out of the water by the buoyancy of the bottom of the dock. The side walls act as floats to prevent the dock sinking too rapidly, and eventually from being entirely submerged.

The operation is performed in this way, water is allowed to flow into the different compartments forming the base, by means of sluices, and distributing pipes; the dock then gradually sinks, until the buoyancy of the chambers, forming the side walls, becomes equal to the weight of the entire structure; that is, when it is desired to sink the dock to its greatest depth for the purpose of taking in the deepest draught ship the dock is intended for, for vessels of less draught it is only allowed to sink to a depth sufficient for the particular vessel. The vessel is then hauled in between the walls, and the engines and pumps of the dock set to work to discharge the water from the bottom or base; when empty, it is capable of sustaining a weight of ship (less the weight of the dock), equal to the total displacement of the bottom or base. The vessel is shored up in the usual manner adopted in the ordinary graving dock.

The dock is entirely of iron, with the exception of the decks, shoring steps or altars and fenders, which are of timber. It is strengthened both longitudinally and transversely by bulkheads, which form the divisions of the chambers, as well as by intermediate lattice framing, which give the structure great stiffness.

The dock for Carthagena was commenced in 1859, sent out in pieces from England, and erected at Carthagena in a shallow basin prepared for the purpose, and when completed water was let into the basin and the dock floated out. When first floated, it was found to have an uniform draught of water of 4 ft. 7 in.; this gives a total displacement of 4,400 tons of sea water, which is equal to the weight of the dock complete.

Some of the largest vessels which it has raised are the frigate Princessa de Asturias, of 3,810 tons, and 21 ft. draught of water, the frigate Villa de Madrid, of 27 ft. 6 in. draught, weight unknown, the ironclad Sarragoza, of 4,972 tons, and 25 feet draught, and the ironclad ship Numancia, of 5,600 tons weight, and 24 ft. 1 inch draught, this latter vessel remained supported for eighty days, without causing any damage to or undue straining of the dock. The weight of this ship was further tested by the depth of flotation of the dock as observed with the ship on it; this was ascertained to be 11 ft. 3 in., giving a total displacement of 10,800 tons of sea water; but on examination of the different chambers it was found that there was about $7\frac{1}{2}$ in. depth of water in the lower ones and $7\frac{1}{4}$ in. in the middle ones, equivalent to 800 tons weight; this added to the weight of the docks, 4,400 tons, gives 5,200 tons, leaving 5,600 tons as the weight of the ship. The dimensions of the Numancia, the largest of the above named vessels, are as follows: length (perpendicular), 316 ft.; extreme breadth, 57 ft.; displacement at load draught, 7,420 tons.

The dimensions of the dock are as follows; length, 320 ft.; breadth outside, 105 ft.; ditto inside, 79 ft.; height outside, 48 ft.; ditto inside, 36 ft. 6 in.

If the few inches of water remaining in the base and middle chambers were entirely removed, the draught of water of the Carthagena Dock, with such a vessel as the Numancia, of 5,600 tons weight, would be 10 ft. 6 in.

The main proportions of the dock are as follows; the length is between 3 and $3\frac{1}{4}$ times the breadth. The width between the walls at the top is $\frac{3}{4}$ of the breadth. The floor of the dock is $\frac{1}{2}$ the breadth. The height of the side walls is somewhat under $\frac{1}{2}$ the breadth. The depth of immersion 1-10th of the breadth. These proportions are suitable for almost all sizes of floating docks of the rectangular form. Thus, supposing a dock to be made capable of lifting and sustaining a vessel like the Achilles, of say 10,000 tons weight, the breadth would be 120 ft., the length 400 ft., the width inside 90 ft., the "floor" 60 ft. in width, and the immersion 12 ft.; total displacement 16,457 tons.

In calculating the height of the metacenter, or the greatest height the weights may be raised above the center of displacement of the immersed body at an angle of inclination, say of 10 deg.; and taking the distance between the centers of gravity of the immersed and emersed portions due to the inclination at two-thirds the total breadth, and multiplying by the portion immersed, and dividing by the total volume immersed into the sine of the angle of inclination, it will give 90.75 ft. for the distance of metacenter from the center of gravity of the volume immersed, or 85.5 ft. above the line of flotation for the Carthagena dock, whereas the center of gravity of the entire structure and ship is calculated to be only 18 ft. above the line of flotation, allowing for a ship of 26 ft. 6 in. draught of water on keel blocks 4 feet in height.

In the dock proposed, the metacenter, is 101.5 ft. above the center of gravity of displacement, or 95.5 ft. above the line of flotation, and the centre of gravity of the dock with the Achilles, is calculated to be only 19 ft. 3 in. above the line of flotation.

In calculating the amount of statical stability of the dock at Carthagena with an immersion due to the weight of such a vessel as the Numancia, of 5,600 tons, it is found that supposing the inclination to be 10 deg., that the moment of stability will be 360 when reduced to feet and tons per foot in length of the dock, or a total of 118,080 tons for 320 ft.; and the dock proposed would have a moment of stability of 549.2 when reduced to feet and tons per foot in length, or a total of 219,680 tons for 400 ft. This is nearly as the cube of the breadth, and directly as the length.

Comparing this latter with a dock of a U-shaped section, with water ballast, like that actually made for Bermuda, as calculated from a lithographic drawing, giving the particulars of this dock, it is found that the moment of stability equals 660 foot-tons per foot in length, or for the length of 333 ft., a total of 219,780 ft.-tons, or about the same as the one proposed, of a rectangular form.

A further comparison of the dimensions, weight of ship to be docked, height of metacenter of these two forms of docks, may not be without interest:

	U-shaped Section.	Rectangular Section.
Available length of dock for the largest ship....	333 ft.	400 ft.
Extreme outside breadth..	123 ft. 9 in.	120 ft.
Extreme inside breadth...	85 ft.	90 ft.
Breadth of "floor".......	50 ft.	60 ft.
Draught of water with heaviest ship.	40 ft.	12 ft.
Area of immersed section ditto................	4,000 sq. ft.	1,440 tons.
Greatest weight of ship capable of being docked	8,000 tons.	10,000 tons.
Weight of dock..........	8,350 tons.	6,475 tons.
Center of displacement below line of flotation.	18 ft.	6 ft.
Distance of metacenter from center of displacement............	38 ft. 6 in.	101 ft. 6 in.
Distance of center of gravity from center of displacement.........	5 ft.	25.3 ft.
Centre of gravity above or below line of flotation.	13 ft. 3 in. below.	19 ft. above.
Moment of stability per foot in length of dock..	660 tons.	549.2 tons.
Total for whole length of dock................	219,780 tons.	219,680 tons.
Draught of water to take in a ship of 26 feet draught with keel blocks 4 feet in length.......	50 ft.	45 ft.

From the above comparison, it will be seen that a dock of rectangular form of the same proportion as that of Carthagena, will have the same total stability as the U form of dock, require about one-fifth less material for its construction, and be capable of supporting a longer ship of one-quarter greater weight, and with less draught of water. Moreover, the arrangements for docking are less complicated; for when the ship is once on the keel blocks, pumping is the only operation to be performed, as there are neither gates nor caissons to close in the ends.

To represent the relative stability of different forms of section in a clear and simple manner (although not so accurately as may be found geometrically or mathematically), the following table is compiled from experiments on different sections made of thin copper, to a scale of 10 ft. to the inch. The models were all 9 in. long; the leverage was taken at 8 in. from the central line of the model.

The lead weights representing the ship were cylindrical, and supported on their axis, at a distance representing the height of the center of gravity of the ship, above the floor of the dock of 27 ft. 6 in.

In the table, A and B represent sections of docks, of the form proposed and that actually executed. It will be seen on comparing the inclination of these two forms with the same weight and leverage, that B, the U shape, gives greater stability per unit of length than A the ⊔ shape, but as the model U was made by mistake to represent 127 ft. 6 in. in breadth instead of 123 ft. 9 in., the relative stability as shown by the angle of inclination is somewhat greater than calculation indicates.

The model C shows how the stability of the same form of section may be increased, by the addition of water ballast at the bottom.

The model D, segmental form, may, with the addition of water ballast, have nearly a stability equivalent to the form A.

The model E represents the Carthagena dock, with its angles of inclination, and with the same weight and leverage as the other models.

Although it may be seen from this that other forms may have a stability equivalent to that of the rectangular or flat form, it can only be done by the addition of a considerable amount of water ballast, which so increases the draught of the dock as to necessitate the ends being closed in.

The Carthagena dock, as before mentioned, was sent out from this country in pieces, and erected in a shallow basin made for that purpose, at Carthagena; this on the whole (when practicable) seems the most safe and simple plan, and the basin is moreover available when required for taking in the floating dock for the purpose of cleaning, painting, or repairing.

Wooden floating docks of somewhat similar section to that of Carthagena have been towed to their place of destination, as was the Pola dock, from Venice, the Havanna dock, from New Orleans, and more recently, that of Alexandria, from the south of France, but the square ends of this form are no doubt ill adapted for being towed through the water.

In order to meet this difficulty, when it was contemplated to tow a dock across the Atlantic, a modified arrangement of the rectangular form was proposed by Messrs. Rennie, better adapted for being towed through the water. The side walls were to be reduced to about two-thirds of the length of the floor of the dock, the rectangular ends of the floor to have been rounded off so as to form pointed ends, upon which temporary sides were to be raised to the required height, in order that the dock might be decked over from end to end; this deck, together with the temporary sides, would have to be removed on arrival at its destination.

Considering the length of the voyage, it was thought that the empty space below the deck might be available for the stowage of coals and other stores to supply (during the voyage, the steamers employed to tow the dock out. This form of dock would not have required a basin as at Carthagena, and the necessary repairs could have been effected by means of a rectangular iron box lowered under the dock, and placed against the defective part, and the water pumped out from within it. The joints between the box and the bottom of the dock being previously made water-tight by means of an elastic substance, or the water kept out by a pressure of air, which, in this case, would not have exceeded 3 lb. per square inch.

In conclusion, it is considered that floating docks of the form and proportions to that of Carthagena will have ample stability for the heaviest ship to be docked.

That it is of the simplest construction.

That the smallest amount of material for a given strength and stiffness will be used in its construction.

That the cost will be less than for other forms of section.

That the simplest docking arrangements and safety of the dock are best attained by that form.

And lastly, that by the modification suggested in the paper, they may be towed with comparative safety to any part of the world.

A Table of Experiments on the Stability of different Sections of floating Docks, made on Copper Models. Scale of 10 ft. = 1 in.

Form of Section.	Weight of model in ounces.	Weight representing ship in ounces.	Approximate proportion of dock to ship.	Breadth of model to scale in feet.	Height of center of gravity of ship from floor to scale in feet.	Degree of inclination with weights, at a leverage of 8 in.			
						1 oz.	2 oz.	4 oz.	8 oz.
				ft. in.	ft. in.	deg. m.	deg. m.	deg. m.	deg. m.
A ⎵	....	....	....	......	......	0 35	1 29	3 2	7 7
	48½	49½	1:1	120 0	27 6	0 52	2 11	3 57	9 6
	....	73½	3:2	......	......	1 29	2 35	4 35	10 6
B U	....	....	....	......	......	0 31	1 12	3 49	5 50
	42	49½	1:1	127 6	27 6	0 24	0 59	3 26	5 36
With water ballast...........	....	73½	5:3	......	......	0 21	0 55	3 6	4 14
C ⎵	....	....	....	......	......	0 55	1 29	3 53	8 22
Without water ballast.........	....	94½	1:1	......	......	0 58	1 57	5 9	10 6
Without water ballast........	48½	73½	3:2	120 0	27 6	1 57	3 5	5 43	12 8
With water ballast............	....	....	....	......	......	0 52	1 26	2 45	6 28
With water ballast............	..	49½	1:1	......	......	1 16	2 7	3 22	8 18
With water ballast............	....	73½	3:2	......	......	1 57	3 9	4 45	9 19
D ◡	....	....	....	......	....	3 43	6 51	14 34	
Without water ballast........	....	73½	3:2	.....	......	2 28	3 53	7 28	
With water ballast............	48½	....	....	120 0	27 6	1 43	3 23	7 24	14 2
With water ballast............	....	49½	1:1	......	......	1 23	2 27	5 9	10 2
With water ballast............	....	73½	3:2	..... .	......	1 23	2 51	5 36	10 32
E ⎵	....	....	....	......	......	0 31	1 33	3 37	8 5
do	30½	49½	5:3	105 0	27 5	1 26	2 35	5 43	12 15
do	....	73½	7:3	......	......	2 11	3 2	7 7	14 48
F U with water ballast......	....	....	....	......	......	6 22	12 48		
	32	49½	5:3	80 0	27 5	9 19	14 52		
	....	73½	7:3	......	......	7 14	12 31		

THE CENTRAL RAIL SYSTEM.

ABSTRACT OF REMARKS BEFORE THE SOCIETY OF FRENCH CIVIL ENGINEERS.

From the "Compte Rendu des Séances." Translated from "Annales du Génie Civil."

For some years the development of railways has gradually given rise to a new problem for engineers, viz: the construction of engines capable of overcoming heavy grades without involving any considerable change in the present systems of *exploitation.* At first, inclined planes were used, up which the trains were drawn by cables; then the Engerth engines, and engines constructed for the Northern railway, &c.; latterly, the funicular system of M. Agudio, and finally, the Fell engine, working upon a central rail, as proposed by Baron Seguier. A similar engine was discussed by M. de Landsèe, before the Society of Civil Engineers at their last session in November. He remarked that the experiment of crossing Mont Cenis had been favorable to the central rail, which permitted the ascent of grades hitherto unused in railways. The engines, through the supplementary adhesion obtained by means of a group of horizontal wheels upon a median rail, have a tractive force equal to at least twice the weight of the engine. He has laid down the principle, in the plan which he has developed, that the engine for the central rail should be able to operate upon an ordinary road at certain points. This condition seemed necessary to him in order that its work may be done easily and conveniently. He accordingly supposes the median rail to be absent at switches, on bridges and at all parts of the road where the grade is easy enough to dispense with it. The locomotives should be adapted to ascend grades of 70 millimeters per meter (369.6 feet per mile), with curves of 50 to 60 meters radius. The type of engine which seemed to him best suited to the case was that having four coupled wheels. The proposed engine weighs 25,000 kilog. without load, and 26,000 kilog. loaded (28 or 30 tons), each axle sustaining 13,400 kilog—a moderate load for steel rails. According to the tables of M. Vuillemin, this engine, on a horizontal track, could draw 400 tons, but in a mountainous country such a load would be excessive, the maximum being 130 tons, and M. de Landsèe has calculated that for trains of 125 and 85 tons, this engine can ascend grades with the following velocities, &c.:

Velocity in kilomet. per hour.	Velocity in miles per hour.	Supplementary adhesion in tons.	Train 125 tons grade.		Train 85 tons grade.	
			Millim.	Feet pr mile.	Millim.	Feet pr mile.
20	12.4	0.	16.8	88.7	24.3	128.3
14	9.	28.8	41.3	218.	58.2	307.3
10	6.2	30.	50.	264.	70.	369.6

M. de Landsèe shows, that for engines weighing 20 tons loaded, and 17.5 tons light, on a road 1.10 m. guage, a median rail will be necessary for a train of 60 tons when the grade exceeds 137.3 feet per mile; with a supplementary adhesion equal to the weight of the engine, grades of 322 ft. per mile are admissible; and reducing speed to 6.2 miles per hour, the inclination, with a maximum adhesion, may be 369.6 ft. per mile. With engines weighing but 10 tons, under the foregoing conditions, the weight of the train may still be 30 tons on a grade of 369.6 ft. per mile. Since it results, from the experiments of M. Forquenot, that the evaporating power of engines depends upon the rapidity of exhausts, and therefore upon the speed of the train, M. de Landsèe suggests the use of four cylinders, two to drive the vertical, and two the horizontal wheels; thus attaining 8.884 exhausts per second for an engine moving 12.4 miles per hour, with with wheels of .80 m. (2 ft. 8 in). In such a case, the boiler, in the ascent of a grade of 369.6 ft. per mile, will have but 87 sq. meters of heating surface at a pressure of 10 kilog. per sq. cent, with a back pressure of 1.50 kilog. per sq. cent. The two pairs of cylinders being independent of each other, the engine can be run without using the horizontal wheels. The coupling of the exterior and interior wheels is effected by the steam; for this purpose the movement of the valves is taken from the rear wheel and transmitted to the valves by means of two distinct levers. A relieving axle is common to the two pairs of cylinders. The admission of steam to each pair is controlled by a special regulator, allowing the starting or stopping of the horizontal wheels while the vertical ones are in full motion. The grip of the horizontal wheels is given by means of a lever at the command of the engineer, and a guage is provided which shows the amount of grip. The coupling is effected by means of two small bevel gears. The real object of the coupling is not so much to transmit a great effort, as to ensure uniform motion and the passing of centers—each pair of wheels being controlled by one cylinder. Owing to the practicability of dispensing with the supplementary adhesion, this engine may be classified with other types in use, and can travel on any road in actual operation.

In answer to some remarks on the subject, M. de Landsèe observed, that a single distribution was employed merely for the purpose of simplifying the mechanism, but that nothing would prevent the use of separate distributions for each pair of cylinders.

PASSENGER STEAMSHIPS.

From "Engineering."

The gradual growth of science and experience has been attended with the most striking changes in the material, size, form, structure, machinery and working results of ocean passenger steamships. Where we had timber-built ships, all, or nearly all, are now built of iron; where the tonnage was once 1,000 tons, or so, it is now three times as much, or even more. Where the lines were once full, and the beam wide in proportion to the length, we now see sharp, fine, fore-and-aft bodies, and lengths of from eight to ten, and even eleven times the beam. The hulls, even when referring to iron ships only, have been greatly changed in structure; where only paddle engines were employed, screw engines are now almost universal; and where we once had but ten knots, we now have fourteen, with the same, if not an even less, consumption of fuel, although the difference in propelling work done represents a difference even greater than that between the cubes of these speeds, or that between 1,000 and 2,744.

It may be questioned whether naval art has not advanced more rapidly than any other branch of structural and mechanical science, and even admitting that it has, there still appears to be a wide field for its further progress. There are many reasons why passenger steamships should undergo further changes as radical as those so well known to be going on in the navy, and it may happen, and that at no distant time, that masts, spars and sails will be dispensed with altogether, as indeed, for very fast steaming, they must be, inasmuch as, at high speeds, the point is soon reached where sails, instead of aiding, only retard the progress of a ship.

Apart from questions of masting and rigging, it is possible also that a great change may take place in the size and form of passenger steamships. For the same displacement longer, wider and shallower ships seem desirable. It is not depth, or great draught of water, that is wanted in passenger vessels, but deck room, and, generally, open-space and light. These are the great requisites for ocean passenger traffic. For convenience of comparison merely, we may suppose two vessels of rectangular form; in other words, they shall be rectangular boxes. Each shall have a length equal to eight times the beam. Let one be 320 ft. long, 40 ft. beam, and draw 20 ft. of water, thus displacing 7,314 tons, and presenting 27,200 square feet of bottom, side and end surface, or skin, under water. The area of immersed midship section would be 800 square feet.

Another ship, having the same displacement, might be made 403 ft. long, 50.4 ft. wide, and 12.6 ft. deep. Its "skin," or under water surface, would be 31,752 sq. ft. in extent, but its midship section would be only 635 square feet in extent. Its deck area would be 20,320 square feet, or nearly half an acre, as against 12,800 square feet on the other and deeper vessel. This comparison refers, for convenience only, to rectangular boxes, but in both cases the vessels are eight beams in length, and the same proportions of deck area, frictional surface, and midship section would hold good when these boxes were hewed to the forms of fast steaming ocean ships. In plan, the lines, excepting only in scale, would be identical in both, the difference being only in the transverse section. The longer and wider ship would have a greater superficial extent of hull and deck, and, consequently, a heavier hull, but, possibly, she might have one deck less than the shorter, narrower and deeper ship. The longer ship would also, perhaps, require additional stiffening to compensate for her shallowness, not so much with reference to her riding the waves, but for her strength in the event of taking the ground or going upon a rock. She would, in any case, be much the roomer and easier passenger ship, and it is a question whether she would not require less power to drive her. The elements of this question appear to be well within grasp.

It has been the fashion among many naval architects of late years to attribute the greater portion of the resistances to vessels driven through the water to skin friction. Yet our two imaginary rectangular boxes, moving at 14 knots an hour, or 23.6 ft. per second (and as for this matter they need only have a rectangular midship section), displace respectively 540 tons and 428 tons of water per second. This water must absolutely be moved out of the way, and the power expended in putting it into motion varies according to the form of the ship, with the fineness of the lines at and below the water level. All ships must displace their own weight of water in running from about one-half to three-quarters of their own length, according to the fineness of their lines. If the average velocity given to the water be computed, as it may be, with some pains, at each successive depth of, say, a foot of draught, the power expended on this work alone may be readily calculated, and it will in all cases be found to form a very large, or let us say the larger, portion of the total power actually and effectively exerted in propulsion, this power being, on the average, but about two-thirds of the indicated power of the engines. It is, of course, supposed that the ship is all the time in hydrostatic equilibrium at both ends, the water running in at the stern and under the quarters exactly as fast as it displaced at the bows—and the mistake must not be made of supposing that the influent water compensates, in the least degree, for the loss of power in forcing aside the water in front. In this comparison, the longer, wider, and shallower ship, having but 635 square feet of midship section, would have the advantage over the shorter, narrower, and deeper ship of 800 square feet of midship section, the difference being in the exact ratio of the midship sections themselves. On the other hand, however, the longer ship would have a wetted surface almost exactly one-sixth greater than the shorter ship. Hydraulic friction is independent of pressure or head of water, being the same per square foot at the same velocity at all depths. Colonel Beaufoy found the skin friction of each square foot of painted wood to be 1.3 lb. at 13 knots an hour, and, according to his experiments (although they were made some seventy years ago, and possibly under circumstances of error of observation), he found the friction to increase in a proportion less than as the squares of the velocities. Applied to the case of steam vessels, it is demonstrable that skin friction, except in very long, very fine, and very shallow vessels does not form the principal resistance to motion. And in the cases of the two vessels already supposed, the somewhat greater skin friction of the longer ship would be much more than compensated by its lesser midship section, requiring proportionately less power to drive it (the lines being the same) at a given speed. Which of the two vessels would be the roomier, lighter, and more airy, as well as drier and easier in a sea way, we need not stop to discuss, although the subject is one to which we shall return.

THE ÆSTHETICS OF CONSTRUCTION.

From a paper read before the Liverpool Architectural Society, by Mr. G. F. Deacon, C. E.

The subject of this paper is the consideration of the conditions under which we are pleasurably impressed by the presence, in our structures, of those natural laws with which we have become familiar, in a greater degree perhaps than we are prepared to believe, by the senses of sight and touch; and not of necessity by that higher mental power which analyzes mathematically the action of these laws. I only speak of the absence of mathematical analysis in the minds of those for whom we build, and do not by any means suggest its exclusion from the minds of the builders. I have always believed that the distinction between the professions of the architect and the engineer is, or ought to be a distinction rather of degree than of kind. We are both of us constructors. We must investigate in common the resistance of materials to the simple strains; those, for instance, of compression, shearing, and tension; and we must, to become masters of our subject, be conversant, though perhaps in a different degree, with the more complex calculations arising from the combination of such strains, either in the same piece of a structure, or in pieces depending for their support upon one another. We must both of us consider, without prejudice, these elements in the works of eminent men who have preceded us, not with a view to servile imitation, but as a safe and well-tried foundation upon which to erect original, and it is to be hoped, better works of our own.

This cursory glance at the minimum amount of scientific knowledge which it appears to me we ought to possess in common, suggests the consideration of that particular branch of æsthetics included under the general term *decoration*, which is altogether independent of construction, and which is excluded from the more immediate subject of this paper.

Our scientific speculations, which are themselves subservient to the adaptability of the result to the end in view, having brought the design in which we are engaged to a certain point, we must, in carrying out our enterprise, and without in any way hiding the work produced by our reasoning faculties, exercise in a greater or less degree our imaginative faculties; often for the purpose of adding pleasing outline or relief, always with a view to the development of that intrinsic beauty which, as I hope to show, is rarely absent from scientifically designed structures.

Agreeable sensations arise in our minds from the contemplation of the beautiful in nature and the beautiful in art, from two distinctly different causes; the one depending solely upon our appreciation of the action of the mechanical forces of nature, the other affecting our senses in virtue of certain distributions of form, color, or light and shade, for which we can lay down but few rules, and those of a merely empirical nature.

Take in your hand a frond of the common lady-fern. It has, for some reason, a most pleasing effect on the eye, and you call it beautiful. Paste the same frond on a sheet of paper in a vertical position, and to most minds more than half its beauty will have vanished. And why? On the first impulse one would be inclined to answer, "because it formerly hung in a beautiful curve, and we have now rendered it rigid and straight;" but a little consideration will show the incompleteness of such a reply. The circle is a beautiful curve, so is the spiral, so is the cycloid; but the fern, when bent into any of these, will have but little more beauty than it had as a straight line. Only one curve will answer the purpose, and that is the curve into which it naturally falls, the curve in which the force of gravity is exactly balanced by the resistance of the stalk to flexure.

Innumerable examples of a similar nature might be adduced, and I think they would one and all show, "that there is a pleasurable effect produced upon the mind by forms resulting from, or balanced by, the direct action of the mechanical forces of nature, when those forces act in a manner which we apprehend intuitively, and are not complicated in their mode of producing their effect upon the senses by artifical means, or by the superimposition of one upon another." And this result is evidently altogether independent of the arrangement of the component parts—a division of the subject to which I have already alluded, as including all embellishments not necessary to those conditions of stability which the ordinary mind is capable of appreciating, but which may nevertheless be introduced to enhance the beauty of the structure.

The first of these effects appears to have a peculiar interest for the engineer, as it is the basis of a great problem; namely, how he is to produce, in those works which are pre-eminently dependent for beauty, on their lines of construction, such forms as the mind will at once apprehend as curves natural to the conditions involved, and which it will not be slow to call beautiful; in short, such curves as are known by engineers as lines of equilibrium. The second, or decorative effect, it is the more immediate object of the artist to produce, and in all cases it should be subordinate and subsidiary to the first.

For the purpose of illustrating my statements, or, I would rather say, as the best arguments that I can adduce, I have collected engravings and photographs of a few of each type of designs for iron bridges executed or proposed; and I have numbered these types, not according to their scientific classification, but rather as they produce a pleasing effect, or the reverse.

Type 1. Box and plate girders.
" 2. Lattice girders.
" 3. Bowstring girders.
" 4. Arched ribs with braced spandrels.
" 5. Suspension-bridge with stiffening girders.
" 6. The continuous parabolic system.
" 7. Simple suspension-bridge with vertical rods.

If we consider for a moment the disagreeable impression produced upon us by the first of these types (and every Englishman has ample opportunities for considering it), we cannot fail to notice that it does not altogether arise from the monotonous oblong form, or even from the flat uninteresting face of the structure. Cover it with moldings and ornaments of cast iron—paint it in the best taste—decorate it as you will—you cannot redeem it from its uncompromising ugliness. And why? Because it appears to be out of place; it is a form which seems to want some additional support; it is essentially deceptive. We cannot appreciate the beauty of construction, the principles of which we do not instinctively comprehend. In a limited sense those principles are correct enough. In the molecular structure of every straight beam there are curves of direct tension and compression, which clear up the mystery at once. The lines of compression are concave downwards, those of tension concave upwards. They cross each other in every case at right angles, and each cuts the neutral surface of the beam at an angle of 45°.

Although the two halves are in all respects similar, there are not two points in the half elevation of the web and flanges, at which the stress is at once the same in amount and direction. Along each individual curve the stress varies from center to end, and every curve represents an amount of stress differing from that of every other. Then what an infinitely complicated piece of workmanship we should have if we attempted to vary the section of our wrought iron plates, in proportion to the duty that each point in their elevation has to perform. Practically we cannot do this. It is for the engineer to determine how far he can approximate to the theoretical conditions involved, and thus save material without necessitating more labor than the value of that material represents; and in most cases this can be done with great advantage. In small wrought iron girders we may, perhaps, by due attention to the principles of stress, save fifteen per cent of the material necessary in a girder of equal strength, but of uniform section, and that without adding to the labor in the least. This percentage, however, is but a fraction of the weight which theoretical perfection represents as lost.

This type, then, is essentially bad in respect of its response to the theoretical conditions of a minimum weight of material. Nevertheless, in small spans the economy of labor consequent on simplicity of construction often compensates for this defect.

Type second is the straight lattice girder; and here the lines of stress are guided from their natural curves, and concentrated in the flanges and diagonals. This fact, however, does not assist the mind in conceiving the mode of action of the beam, and I am inclined to think that all the superiority of appearance is to be traced to the decorative effect produced by the open lattice work, and the reduction of apparent weight. Among the best known bridges of this class are, in England, those at Crumlin and Runcorn, and on the Continent those over the Rhine, at Cologne, and at Kehl, near Strasburg, and that over the Vistula at Dirschau. But one and all of these must be regarded as failures in an æsthetic sense. Probably Mr. Baker's towers at Runcorn, and the piers at Dirschau, are most in keeping with the works. The Gothic piers of the bridge at Kehl have a singular effect. Their appearance is very striking, but they do not harmonize well with the long horizontal lines of the girder, or with its lattice bars arranged at angles of 45°. The proximity of Strasburg Cathedral, too, is not calculated to impress one in favor of that puny cast iron architecture.

The bowstring girder is our next type, and it includes all those in which the top or bottom flange, or each, consists of a segmental or parabolic rib, connected together by diagonal lattice bars. The best known of those which have both flanges curved are Brunel's bridge at Saltash, and that over the Rhine at Mayence. All these structures are, as regards the iron work, more natural than either of the preceding types, and we must accord to them the merit of giving us the first clear idea of the manner in which they do their work. We may not feel satisfied with their appearance, but we must admit that it is, or may be made, much superior to that of either of the straight types.

We now come to the arch, respecting which I shall say more hereafter, but assuredly we cannot hesitate to assign to it, in our classification, a higher place than we would to those already mentioned. The mind at once perceives the natural and efficient manner in which it supports the load to which it is subject.

Our fifth type is the suspension bridge, stiffened in such a manner by lattice work as to be capable of bearing, without undue vibration, heavy rolling loads. It is sufficiently obvious that the effect of the simple parabolic or catenarian curve is, in a great measure, marred by the proportions of the stiffening girder.

In the late Paris Exhibition were exhibited two striking drawings, by Herr Carl von Ruppert, for bridges across the Bosphorus, and over one of the greatest chasms in the tertiary limestones of the Balkan. In carrying out the Austrian project of a railway to Asia Minor, it will be necessary to cross these places, and Von Ruppert has probably solved the difficulty in a very complete manner. It is well to mention that his investigations have been published, and they can leave no doubt in the mind of the reader that the Austrian engineer has brought together principles already well understood, with a boldness and originality resulting in a complete success.

There is but one more, and that is the pure suspension bridge. We cannot improve upon that simple catenary. Its mode of action is apparent at a glance, and its curve is evidently a natural one. But, unfortunately, we have no means of rendering it sufficiently rigid for railway purposes, without destroying its chief æsthetic characteristics.

Thus far I have endeavored to lead you through the general principles, in virtue of which each of the seven types supports its load. You may feel inclined to change the order of one or two, but that will not affect the general result.

Had I based the classification upon the relative economy of material, upon the absolute weight of the superstructure which each would have required for the same span, and to bear the same moving load, it is at least gratifying to know that the arrangment would have been precisely the same, and that, although in small spans the order of ultimate economy is somewhat changed by the different proportions of labor to material required, it would not be felt in the large spans.

These general facts have been long known to the engineer; but Mr. Benjamin Baker has recently reduced them to approximately correct figures for different lengths of railway bridges up to the limiting spans, and I have prepared, from his investigations, the annexed table, showing the weights of material in spans of 700 ft., and also in spans 100 ft. less than the limiting spans. The types are in principle the same as those I have described, though not arranged quite as Mr. Baker classed them.

I have now laid before you the general arguments which, you will probably admit, prove, at least in regard to great bridges, the truth of the statement that, in equal spans, the æsthetic properties of the lines of the structure vary in direct proportion to the simplicity of the design, in a scientific sense, and in the inverse ratio of its actual cost.

These results are sufficiently remarkable; and if we can in every case find beauty and science walking hand in hand, as here, shall we not be able to do more in the cause of both than we do at present? And this, I think, we can find in our works of stone and brick, without either the conditions of great size, or the cost of extra labor.

Table compiled from Mr. Baker's Analysis, showing the Approximate Weights of Wrought Iron or Steel in the Superstructure of Railway Bridges of six different types; the working stress of the iron being taken at 4 tons, and that of the steel at $6\frac{1}{2}$ tons per square inch of sectional area:

Description.	700 ft. Span. Approximate weight in tons.		Limiting Span minus 100 ft.	
	Iron.	Steel.	Weight of steel in tons.	Length of Span in feet.
Box girder	51,030	.....	....	.....
Lattice girder	17,360	4,410	27,315	900
Bowstring girder	6,650	2,730	68,055	1,300
Arched ribs with braced spandrels	3,500	1,995	364,420	1,900
Suspension with stiffening girder	3,045	1,715	276,450	1,900
Continuous girder with varying depth*	2,660	1,820	1,120,000	3,200

THE CORROSION OF BOILERS.

By Norman W. Wheeler.

The writer is induced to put forward a few crude thoughts in the hope that some competent chemist will experimentally determine whether his surmises are correct or otherwise.

The corrosion of boilers worked in connection with surface condensers is in great part attributed to a galvanic action induced by the condenser. But galvanic action does not establish itself spontaneously; some sort of chemical decomposition, or degradation of metals or other bodies being, so far as we know, a condition precedent, so that it becomes a question whether the corrosion observed is not the cause rather than the effect of the galvanic excitation observed.

When water is repeatedly vaporized and

* This type is nearly equivalent to Von Ruppert's system.

condensed, with very little exposure to the atmosphere, as is the case in practice, it becomes to a great degree deærated, but the question as to which of the numerous gases existing in natural water is first eliminated remains unanswered. If those gases, of which water absorbs the greatest bulk, cling to it with the greatest tenacity, a considerable part of the destructive effect is thereby accounted for. It is stated by good authorities that water absorbs at common temperatures its own bulk of carbonic acid, one twenty-fifth its bulk of oxygen, and still less of nitrogen. If, when water is deærated by heating, the neutral gas nitrogen is first expelled, the corrosive power of the water should be exalted by its atmosphere, so to speak, of carbonic acid and oxygen; and if, during the exposure to the air in the air pump and hot well, the water absorbs the gases in ratio of their supposed affinities, we should have in the boiler a pretty active solution of carbonic acid in oxygenized water, from which we ought to expect corrosion of the metal of lowest chemical rank exposed to its power, corresponding with the observed facts.

A case encouraging the belief in the seriate elimination and absorption of gases, occurred in the writer's practice in 1864. Four vessels were built for the Government, with return flue boilers and "high pressure" engines, but the steam was condensed, for the sake of fresh feed water, in open surface condensers; that is, condensers making no vacuum, but fitted with tubes and circulating pumps, and the steam spaces in the condensers communicating with the atmosphere through pipes. The condenser tubes were made of iron and galvanized, for the purpose of avoiding the corrosion of the boilers. The feed-water was drawn by the feed-pumps directly from the condensers. As a matter of convenience, the atmospheric pipes were led from the condensers and opened into the smoke pipes, so that when an exhaust took place, the vapor was for an instant driven out through the atmospheric pipe, and because of the continuous condensation, the gases in the smoke pipe were drawn back toward or into the condenser between the successive exhausts, thus keeping up a pulsation and swaying back and forth of vapor and gases in the atmospheric pipes, which, although made of copper, were eaten into holes in a few days. The pipes passed overhead through the fire rooms, and the continual dripping of hot water made those places very uncomfortable. The corrosion of the boilers was marked and unmistakable within a month.

The atmospheric pipes were then changed and led to the open air, and the corrosion of both boilers and pipes apparently ceased, and was not again observed while the vessels were within the range of the writer's observation.

It is supposed that carbonic acid was absorbed rapidly by the vapor and condensed water in the atmospheric pipes, the supply being derived from the gases of combustion, and the acidulated water passed into the boilers by the feed pumps.

Now, if it be proven that the water, while exposed in the hot well of an ordinary engine, absorbs oxygen and separates it from the nitrogen of the air, and that the nascent carbon of the oils, used to lubricate the internal parts of the engine, is seized by the oxygen when the oils are decomposed by the heat of the steam, we shall be able to account for an amount of carbonic acid in the boilers working in connection with common surface condensers, sufficient to destroy them rapidly.

WIRE ROADS.

From "The Engineer."

The great defect of the modern railway is, that the system does not admit of general use. It is true that a railway can be laid down and worked by locomotive power in almost any conceivable country, provided there is sufficient capital available for its construction, and sufficient traffic to pay for working it. But thousands of cases will present themselves to the engineer in which, although a fair amount of traffic may be expected, it is morally certain that this traffic could under no possible circumstances prove remunerative, for the simple reason that the capital expended would of necessity be out of all proportion to the money received for the carriage of goods or the conveyance of passengers. As we cheapen railways we increase their sphere of usefulness; and were it possible to reduce the cost of railways below that of common roads, and to render the conditions of working such, that on them, as on a canal, private individuals could run private vehicles, it is more than probable that common roads would cease to have existence, their place being taken by tramways or public railroads. Numerous attempts have been made to reduce the cost of railroads, but with, for obvious reasons, very little success. The cheapest single line of 4 ft. 8½ in. gauge, which it is possible to lay in an easy country will cost, at least, £3,000 per mile. If the country is difficult or hilly, the expense of construction may very well rise to ten times the sum. Railways represent the most perfect mode of transit yet produced in one sense, and it is therefore to be regretted that they are not more generally applicable to all the purposes of locomotion than is at present the case; but it is, we think, still more to be regretted that there is no prospect whatever that they will ever become much more useful than they are now. A good deal remains to be done as regards tramways, which partake intimately of the nature of railways without being railways in the truest or highest sense. But even when tramways have received that enormous development of which the system is probably capable, conditions will still constantly exist under which it will be impossible to resort to their use; and the same truth applies to the ordinary macadamized or graveled road. Stretching a point, every ordinary highway and parish road may be regarded as the substructure for a tramway. No tram can be laid on a substructure much worse than our third and fourth-rate country-roads. Therefore it may be taken for granted that where a road can be made a tram may be laid, and also that where a road cannot be constructed no tramway can be laid down. But in almost every civilized or partially civilized country in the world, circumstances occur under which, though means of transit are required, it would be impossible to provide them, either in the shape of railroads, tramways, or common roads, at a price which would justify their construction even by a state, much less by any company of adventurers. Therefore it appears that the proposition with which we commenced this article applies to both tramways and common roads as well as to railways, though not with the same force; for both tramways and common roads are open to objections, which do not exist in the case of railroads, far more serious than the want of universal adaptability.

It has long been felt that some efficient means of transit, which might be used under any conceivable conditions, are badly wanted; but it does not appear that much had been done up to a very recent period to supply the want. The popular way out of such a difficulty as that, for example, which presents itself when the ore from an out-of-the-way mine has to be got to a seaport, lies in making a road, buying carts and horses, building stables, and hiring carters; where it happens—and in the colonies it does happen rather often—that no road fit for wheeled carriages can be made, the popular remedy fails of course. There are two substitutes for common roads; one consists of mules and the other of camels. Coolies and elephants we will leave out of the question for the present. Now mules are no doubt very useful, and so are camels; but any of our readers who has had to transport a 20-horse engine, for example, up country on the backs of mules or camels, will agree with us that, although the muleteer of song is a very picturesque creature, the muleteer of fact is, though picturesque, something else as well; and, making the best of mules and camels and their drivers, the great fact still remains, that they carry things slowly, and cost a great deal. In a word, mules and camels no more solve the problem of transport in distant lands, as English capitalists and engineers would have it solved, than a trained hippopotamus, weighing about four tons, and carrying a couple of Kaffirs, represents a perfect means of ordinary locomotion. It would not be easy to estimate the loss which accrues each year to our colonies as a consequence of the want of some means of bringing produce to market. There are coffee plantations in Ceylon, more than 40 per cent of the produce of which is constantly wasted and lost, simply because no efficient means exist of getting the coffee to market down the jungle-clothed sides of hills. The waste and loss of cotton in India, for the same reason, is enormous. In Namaqua land, again, there are valuable mines which cannot be worked because coal costs £8 per ton—half this expense, or more, being incurred in transporting it a few miles up the country on the backs of mules. It is impossible to estimate, indeed, at this moment, how much wealth is lost to the world because no means exist of transporting cotton, and coffee, and ores, and coal, over moderate distances at moderate rates.

Impressed as we are with the importance of this loss, and desiring as we do to see the loss for ever done away with, we have carefully watched every attempt that has been made of recent years to overcome the difficulty. The narrow gauge railways of Queensland; Mr. Brunlees' cheap lines in

South America; the pneumatic dispatch—in which there is more as a means of cheap transit in difficult countries than is at present perceived—these things, and such as these, holding out promise of future good, have all claimed our attention; but very little observation is sufficient to show that they none of them comply with the conditions of the greatest difficulty. Take the case of a coffee plantation in a fertile district on the side of a hill; between it and the nearest port, or the nearest road to a port, lies an impenetrable jungle, deep ravines, and water courses now dry and anon filled with a foaming torrent; the railroad can do nothing for such a case, the pneumatic dispatch is of as little value. What the planter wants is the wings of the dove to take him to the uttermost part of the sea. If he could but fly! If he could but organize a trained troop of flying steeds to take his produce bit by bit over the top of the jungle, across rock, ravine and torrent, then, indeed, the problem would be solved, and the flying steeds would serve a more useful purpose, and do more good than ever Pegasus has done yet.

Now, is this flight impossible? Are the difficulties to be encountered insurmountable? We think not. We have spoken of flying steeds, and we have done so with a purpose. It is evident that if we could construct a road above ground instead of resting on it, neither jungle nor forest need give us trouble. There is a race of pirates in Borneo who live in forests. These people seldom touch ground. Their roads consist of single trunks of trees felled, laid end to end, and carried on suitable uprights for miles through the depth of the forest from the sea shore. The jungle undergrowth is impassable, therefore those people make their road over it. We are all familiar with the rope bridge of South America, across which the traveler is drawn in a basket swinging below the bridge, which consists of a hide cable. In these two, the Borneo tree road and the South American bridge, we have the crude germ of an idea which, properly worked out, may do wonders for the good of mankind.

The only scientific development of the idea yet before the public is Mr. Hodgson's wire railway at Bardon Hill, Leicester, already noticed in our pages.* This line, three miles long, extends from Messrs. Ellis and Everard's granite quarries at Markfield, to Bardon station on a branch of the Midland Railway. At Bardon is a tremendous rotatory crushing machine, capable of converting a couple of hundred tons or so of granite into road metal per day. We need not again describe the wire line put down to transport 100 tons of stone per day to this machine, but never as yet worked up to its full capacity. It will suffice to say that the principle involved consists in suspending a wire rope on wheels fixed to posts placed about thirty-one to the mile, just as are ordinary telegraph posts. The rope runs over a horizontal pulley of considerable diameter at one end, and at the other round a $4\frac{1}{2}$ ft. Fowler's clip drum, driven by a 16-horse portable engine, which is not half loaded. One side of the six miles of endless rope is always traveling toward Markfield, the other side away from it, toward Bardon. The stone is loaded into boxes, which are hung on the rope and run full to Bardon, where they shunt off the rope, are emptied, and sent back to Markfield on the return line. The wire road winds in and out, passing here through a grove, there across pasture lands. In one place it jumps obliquely across the high road with a span of 600 ft. clear. The pace at which the buckets travel is about four miles an hour, the load in each about one cwt., and some thirty buckets come to the mile. The line has now worked for some months most successfully, and we are pleased to hear that in Italy, Spain, and Turkey the system is likely to be extensively adopted. The system is certain to prove infinitely valuable to countries perishing from that inanition due to want of means of internal circulation.

Here we have means of transport provided, by which all obstacles connected with the country are avoided. No doubt objections may be raised to the scheme, and difficulties are certain to be encountered in carrying it out on a large scale. One or two points, however, are certain; it has been proved that the principle can be applied in practice; wire-rope railways are very inexpensive—£150 to £500 per mile; they offer the only certain solution for hitherto insurmountable difficulties, and, lastly, the entire principle is correct. We did intend to speak of the mechanical questions involved, such as the best means of carrying the rope, putting on the buckets, the power consumed, etc.; but these we think best, after all, to speak of at a future

* See "The Engineer" for February 19, 1869.

time when the system shall have been more fully developed, and some inquiry shall have been made into its dynamics. So far the scheme is a mechanical success, and that is about the only point connected with it, save its all but universal applicability to the purposes of transport, with which we have anything to do.

RAISING WATER FROM MINES.

From "The Engineer."

In scarcely any department of the operations necessary to bring our subterranean treasures to the surface, is there greater diversity of comparative working cost than in the process of freeing the mines of water. The men who win our metals have made much more progress in this department than those who get our fossil fuel, as we shall presently see. Meanwhile let us get some idea of the financial significance of the subject by remembering that from the northern coalfield comprising Northumberland and Durham there has every year to be taken water fifteen times the weight of the output of the coal of the district, which, according to the the mines inspectors' last returns, reached, in 1867, a total of 26,500,000 tons. In Staffordshire the water raised is computed at ten times the weight of the coal; but the ratio of cost in each may be assumed to be alike. It is estimated at .343 pence per 1,000 gallons raised 100 ft., or, in other words, per million foot-pounds. This calculation is made upon the basis that the average of the lifts is 384 ft., which is computed to be the average depth of the pits in South Staffordshire; and this, for the purpose of calculation, may be taken as the depth in the northern field. Computed on the quantity of coal raised in 1865, the cost of pumping in the South Staffordshire collieries is estimated by Mr. E. B. Marten at £100,000 a-year, taking £500,000 as the capital employed, and allowing a 5 per cent reduction on this capital. The engines are presumed to work twenty-four hours per day. Taking Mr. Marten's figures for his guide, and adapting them to the 25,000,000 tons raised in the northern district in 1865, Mr. William Waller puts down the yearly cost of pumping the Northumberland and Durham district at £459,200.

How much more this is than need be, may not be accurately concluded, but may, to some slight extent, be imagined from a fact which Mr. Warington W. Smyth has placed upon record. It is that he has watched a large pumping engine in the north which raises water from 105 fathoms deep, in 12-in. lifts, at seven and a-half strokes per minute, with a consumption of twenty to twenty-five tons of slack per day, whilst a similar amount of work is done by a Cornish engine with from two to two and a-third tons. The coal was no doubt inferior in the former case, but the result, he intimates, shows that there are engines in the country consuming upwards of ten times the quantity of coal that is needed for the work accomplished. It is clear that the pumping at our coal mines is not conducted as cheaply as it ought to be, and we have reason to know that even the metal mines of Cornwall might be freed for less money than is now the current charge. What should be the cost of raising 1,000 gallons of water 100 ft.? Mr. Wm. Waller set himself to answer this question in a paper which he communicated to the North of England Mining Engineers during 1857. By the side of the figures as to the assumed average cost in the north of England and in South Staffordshire, he places data obtained under his own observations relating to waterworks. Should any one object that these are not parallel cases, he submits that the mining engine works under more advantageous circumstances; for this reason, that being necessarily in the first instance sufficient to reduce the water, afterwards in keeping it at the reduced level, it is working well within its power and under very economical conditions; whereas, the waterworks engine, having to contend with ever-varying demands, with extra and intermittent exertion, with increased friction and resistance in restricted pipe area, is under every disadvantage. For the purpose of comparison, however, colliery and waterworks engines may be considered as working under similar circumstances.

A most important difference in the duty of several engines in the same undertaking sometimes transpires. This is especially seen in the case of the East London Waterworks Company. It is stated on the authority of Mr. Wicksteed himself that the total cost of lifting a million foot-pounds, taken on the average of several years with different engines is: Single-acting engine, Boulton and Watt, .543 pence; double-acting engine, Boulton and Watt, .358 pence; double-acting engine, Boulton and Watt, .333 pence; Single-acting Cornish, Harvey and Co., .150. Whilst the water company are supposed to give 7s. 6d. a ton for their coal, the average of the East London was 10s. 6d.

The Southwark and Vauxhall Company's total cost is at 10s. a ton for coal, .084 pence; or with five-sevenths for labor, repairs, wear and tear, etc., .144 pence.

The Grand Junction, with coal at 14s. 6d., is set down at for coal alone, .192, while labor, etc., added .276 pence.

The Liverpool Corporation Works present a comparison more nearly approaching the general pumping arrangements of a colliery's engines—both the ordinary crank engine and Cornish type are used; and the cost of pumping is given with great detail and accuracy. There are in Liverpool seven stations with nine engines. At the Bootle station there were three engines, each with beam and crank, and a single-acting bucket pump, and worked direct from the beam of each engine. Only two of these engines were worked together, and they delivered through an air-vessel. At the Bevington Bush station there was a bucket-lift, but it was altered to a plunger, and at once the total cost fell from .789 pence to .201 pence per million foot-pounds. Most of the calculations are based upon the returns for 1849; but, as indicative of the great saving to be effected by a large amount of duty performed, we may state that the engine at the Green-lane station of the Liverpool Company, which is Cornish, with a 56 in. cylinder, and a 9 ft. stroke, by Harvey and Co., which raised 992,000,000 gallons 100 ft. at a total cost of .222 in that year, was raising in 1865 as much as 2,736,000,000 gallons that height, at a total cost of .178 pence, the cost of the coal used being 6s. 10d. ton. And when the Southwark and Vauxhall raised 4,061,000,000 gallons, with coal at 10s. a ton, they did it at a total cost of .144 pence per million foot-pounds. The cost of coal alone at the Green-lane Liverpool engine was .075, and at the Southwark and Vauxhall, .084.

Hence it is concluded that the cost of coal for lifting 1,000 gallons 100 ft. high, or a million foot-pounds, need never exceed one-eighth of a penny where Cornish engines of the best make are employed; and that the total expense, exclusive of the interest of capital for doing this amount of work, might be within one farthing, instead of two or three farthings, which it often is.

"The Engineer" then discusses the South Staffordshire drainage, which is now a tax on the coal raised of 4½d per ton.

STRENGTH AND RESISTANCE OF MATERIALS.—In a paper "on the present state of knowledge of the strength and resistance of materials," read before the Institution of Civil Engineers, May 11, 1869, Mr. Jules Gaudard stated that the theory in the case was closely connected with that of molecular mechanics. But being a branch of that science altogether of practical application, it required only to borrow from scientific theories the principles on which to base rules of construction, simple enough to be of general application and yet sufficiently exact to be used with confidence. The formulæ of strength brought into view, on the one hand, the destructive action of external forces, and, on the other hand, the resisting power of the molecules of the material. External forces were of two kinds: one kind comprised elements directly given, such, for example, as weights; the other kind consisted of reactions—functions of given forces. In certain cases these reactions might easily be found by the science of statics alone, as, for example, in the case of a beam placed on two supports; in other cases they would depend on the changes of form of the solid. It was this, for example, which caused the difficulty of calculation in arches and in continuous beams of several spans. Or, lastly, it might happen that the body in question might not be in a state of equilibrium, but that its particles might oscillate under variable dynamic influences, or forces of inertia. This was the case of concussions, vibrations, etc. These various external forces being determined, it would easily be seen if they tended to cause certain parts of the solid to elongate, or to shorten, or to shear, or to turn round certain axes. These various effects, extension, compression, sliding, torsion, flexure, might further manifest themselves separately, or might combine with each other. Under the action of these forces, the body would necessarily be changed in form; for solids perfectly rigid were only pure abstractions. The study of these changes of form constituted the object of the theory of elasticity. The study of strength, or resistance, had to do with the power which the solid, according to its physical constitution, possessed to maintain, if not its form, at least the cohesion of its parts.

The author then proceeded to consider the forces of various kinds to which materials were subjected, such as extension, compression, sliding, flexure, torsion, and shearing; and in reference to all these, he gave the results and formulæ of the most modern investigations; expressing them at such length as to make them intelligible, but with sufficient conciseness to bring them within reasonable limits of space.

In conclusion, it was remarked that the theory of the strength and resistance of materials touched obscure problems relating to the physical constitution of bodies, and yet its practical character obliged it to be simple. Another motive, also, justified the departure from rigorous exactness, that was, the irregularity of the materials facts; if it was good, in effect, to associate mathematical science with physical phenomena, it was incontestable that these two elements, one always logical, the other frequently capricious, were often separated from each ether.

In spite, however, of these imperfections, the theory of the strength and resistance of materials in its present state constituted an elegant and useful doctrine, which ought to be better known by the majority of constructing engineers, so much did it tend to impress boldness and elegance on designs of all kinds. In any case, the theory, imperfect though it might be, had the great advantage of generalizing facts. Empiricism, if left to itself, would encumber the science of construction with a mass of rules, without reason or connection, well calculated to repel and mystify practical men.

Improved Road Roller.—Gen. Green, of the Croton Aqueduct Department, New York, has introduced a roller consisting of a series of independent discs some $1\frac{1}{2}$ in. thick (that is to say, $1\frac{1}{2}$ in. wide on the tread), and a series of alternate discs of the same width, but of 3 in. less diameter, all mounted on a common shaft, so that the whole roller is grooved like the roll of an iron mill for producing $1\frac{1}{2}$ in. square iron. As each disc moves independently on the shaft, facility of turning and avoidance of scraping while turning, are the result. But the most important result—and it is very important—is the increased hardness and *uniformity* of the road. A long solid roller can hardly be made heavy enough to crush down the protruberances of the surface; hence soft or uneven places are left between them. The grooved roller easily cuts into hard and projecting places, pressing the material laterally as well as vertically, so that the hollows are filled and the material is uniformly condensed.

THE COMPUTATION OF EARTHWORK.

From "Engineering."

We have, from time to time, illustrated and described several different arrangements for the mechanical computation of earthwork, by which the long and tiresome operation of calculating the cubic contents of the cuttings and the embankments of a railway can be substituted for a process of simple inspection, so that the quantities can be registered expeditiously, and with a minimum chance of error. A very ingenious instrument has recently been designed by Mr. W. H. Barlow for this purpose, and which will be found invaluable for making the computations necessary for framing parliamentary estimates, as well as for the more precise earthwork calculations during the progress of actual work. The instrument consists of a wooden circular tray, about 12 in. in diameter, in which are set cardboard discs revolving round a central pin fastened in the tray, and having engraved on their peripheries quantity scales of relative proportion. Upon the edge of the tray is screwed a brass stop, terminating in a flat finger, with a feather edge on one side and a zero inscribed upon its end.

The cardboard scales are of two classes, the height scales, referring to cuttings or embankments, ranging in height from 0 to 75 ft. These are engraved upon the larger disc, which entirely fills the tray, but can be turned round within it upon the center pin; the zero of this scale, in operating the instrument, is made coincident with the feather edge of the brass finger. The other is called the quantity scale, and is applicable for all widths and slopes of the height scales; it is graduated around the complete circle, and represents a total of 100,000 c. yards. This disc. is about 1 in. smaller in diameter than the outer one, which it overlies, and turns freely upon its center; its zero corresponds with that on the end of the brass finger. There is space sufficient upon that part of the under disc exposed beyond the edge of the upper, to allow of four or five height scales being drawn upon it. All these scales, by preference, refer to one formation width, with varying slopes; separate cards being prepared for different widths, and which can be easily placed on the tray by unscrewing the stop and lifting off the upper disc.

Both the height and the quantity scales are but the ordinary earthwork tables graphically stated. In constructing the former, the calculated cubic contents of a bank or cutting, of a certain formation, width, and side slope, forms the extent of the scales, each of the subdivisions of which represent the quantity contained for heights decreasing foot by foot to nothing, a constant length of 66 ft. being maintained, although, if desired, the scale may be divided into shorter lengths. These graduated quantities being thus drawn, are projected with ease upon the circular scales of the disc, and from which the standard quantity scale can be laid off.

In using this instrument, the height scale adapted to the intended slopes and formation width is selected, and its zero is accurately placed against the feather edge of the brass stop by means of a pointer; the disc is then fastened into its position by set screws. Then the zero of the quantity scale, free to revolve, is accurately adjusted to the 0 at the end of the brass stop. The longitudinal section having been divided into chain lengths, a steel pointer is placed on the rim of the quantity scale exactly opposite to that division on the height scale, which corresponds with the height or depth at the first chain. The disc is then brought round until the pointer touches the brass stop. Proceeding in this manner with each chain length in the bank or cutting, the total quantity may be read off on the quantity scale at the zero of the brass finger, provided the quantity does not exceed 100,000 c. yards, which is the total capacity of the complete graduated circle. If the whole contents, therefore, exceed 100,000 cubic yards, that amount must be added to every complete revolution of the quantity scale. It is obvious that the use of this instrument can be extended to computing the quantities to be added or deducted for any formation widths for which height scales are not provided; if the earthwork be first measured up with one base, and afterwards with a smaller one, the difference between the totals will give the cubic contents of a bank or cutting, with a formation width equal to the difference between the two bases used in the computation. This quantity divided by the width will give the cubic contents per foot of formation.

Although as designed no means are provided for computing the contents of banks or cuttings upon sidelong ground, it is obvious that this could be effected by a modification of the quantity scale, which could be adjusted to correspond with varying transverse slopes.

Altogether this instrument is the best adapted for its purpose that we have seen, and we are the more glad to bring it into prominent notice as Mr. Barlow proposes to devote any profits arising from its sale to the Benevolent Fund of the Institution of Civil Engineers.

GUIBAL'S VENTILATING FAN.

From a paper read before the Institution of Mechanical Engineers, by Mr. J. S. E. Swindell.

The fan employed at the Homer Hill Colliery, Cradley, has eight vanes, and revolves on a horizontal shaft within a cylindrical casing of brickwork, by which it is completely enclosed at the sides and circumference, with the exception of a circular aperture in the center of one side for the entrance of the air from the mine, and an outlet opening in the circumference for the discharge of the air into the outlet chimney. The area of the outlet opening is regulated by an adjustable sliding shutter, according to the extent of ventilation required; and the outlet chimney is built with a gradually increasing area up to the top, so as to reduce the velocity of the air at the point of discharge, and thereby prevent the loss of power that would occur in discharging it at the velocity of the fan. The fan is driven direct by a horizontal steam engine working a crank on the end of the fan shaft without the intervention of any gearing. The fan is $16\frac{1}{2}$ ft. diameter and $4\frac{3}{4}$ ft. width, and its usual working speed is 26 revolutions per minute, discharging 13,500 cubic ft. of air per minute; and it can be got up in only about one minute's time to the higher speed of 96 revolutions per minute, discharging then 51,700 cubic ft. of air per minute. The current of air from the mine passes to the ventilator along an inclined drift leading off from the upcast shaft at a little depth below the top; and the top of the upcast shaft is closed by a movable cover, which is lifted by the ascending cage on arriving at the top, the weight of the cover being counterbalanced by weights. This is the first mechanical ventilator that has been applied in the working of the South Staffordshire Thick or Ten-Yard coal; and it has now been running about nine months, without a single stoppage for repairs of any description, and is doing excellent work, the total cost of the fan, with engines and connections, being only about one-third of that of an ordinary ventilating furnace for producing the same amount of ventilation. A comparison of actual working between the furnace and the fan at a colliery in the north of England shows that with a consumption of only two-thirds as much coal, the fan supplies nearly double the amount of air obtained with the ventilating furnace. Several of these ventilators are now at work at collieries in different parts of the country, some of which are as large as 30 ft. diameter and 10 ft. width, capable of delivering 100,000 c. ft. of air per minute; and they are so free from liability to get out of order that no accidents of any consequence to the ventilation have occurred with any of them.

ILLUMINATING POWER OF COAL GAS.

From a paper on "Experiments on the Standards of Comparison Employed for testing the illuminating Power of Coal Gas," read by Mr. T. N. Kirkham, M. Inst. C. E. before the Institution of Civil Engineers.

It was observed that the standards of comparison at present in use were known to be wanting in that uniformity of result necessary for determining with accuracy the difference in the intensities of two lights. But as the amount of the variation had never been clearly defined, the author had instituted a series of experiments for the purpose of ascertaining the extent of these differences.

The instruments employed for testing the illuminating qualities of two flames were founded on the law of optics, that light diverging from a luminous centre diminished in intensity in the ratio of the square of the distance. This principle had been taken advantage of by Count Rumford in the instrument known as the "Jet Photometer," which was described; as was also another method, suggested by Professor Bunsen, which was dependent for its action upon the combination of reflected and transmitted light.

In France, the instrument employed was M. Foucault's modification of that proposed by Count Rumford, as arranged by MM. Dumas and Regnault; while the standard of comparison was the amount of light emitted from grammes of colza oil, specially prepared and verified, burning in a Carcel lamp, of certain fixed proportions, at the rate of 42 grammes (648 grains) per hour; and it was required that the light produced by from 25 litres to 27½ litres (.8625 to .9707 of a cubic foot) of gas, consumed in a Bengel burner of known dimensions, should be of equal power. The mode of conducting an experiment with this instrument was then detailed; and it was explained that during the progress of the experiment, the quantity of gas was regulated, so that the two lights should be maintained of equal intensity. In this way it was possible to compare the consumption of oil with that of the gas, and if the lamp had burned at the specified rate of 42 grammes (648 grains) per hour, the experiments should have been completed in 14 minutes 17 seconds.

In England, the instrument in use was constructed on the Bunsen principle, and the standard of comparison, as defined by Act of Parliament, was a sperm candle, burning at the rate of 120 grains per hour. The gas being consumed at the rate of 5 cubic feet per hour, through an Argand burner having 15 holes, and with a chimney 7 in. high, must be equal, in intensity of light, to 12 such candles.

The instrument by means of which the experiments were made by the author was also constructed on the Bunsen principle, combining all the most approved modifications. It consisted of four photomers, radiating from a common centre in the form of a cross, and each accurately scaled, adjusted, and fitted with every appliance to insure uniformity and precision.

The first series of experiments was undertaken for the purpose, if possible, of arriving at the amount of variation in the illuminating power of candles obtained from the principal manufacturers. Gas was adopted as a standard of comparison; and to insure uniformity in its illuminating power, a sufficient quantity for carrying out the experiments on each occasion was put into a gasholder in the labaratory, the temperature in the latter being always maintained at 62° Fahrenheit. In this series, each of the four photometers was supplied with candles of a particular make, to the use of which it was restricted throughout the day, every successive experiment being made with a separate specimen. All the candles were cut in half and burned from the centre. It was observed that, although the standard candle was fixed by Act of Parliament, as a sperm candle, of six to the pound, burning uniformly at the rate of 120 grains to the hour, yet no such candle was to be obtained; for from various quantities of sperm candles, six to the pound, procured from several manufacturers, the average rate of consumption was 135 grains. This fact had been previously demonstrated by the extended series of experiments carried out by Professors Graham, Leeson, Brande, and Cooper, in 1852. The Parliamentary rate, being abnormal, was so rarely met with, that all operators had been compelled to make corrections for these variations, and had unanimously adopted the ordinary rule of simple proportion for the purpose. It was proposed, therefore, in the analysis of the diagrams exhibiting the results of the experiments, that the candles burning at the rate of 135 grains should be designated "normal standard candles," to distinguish them from the Parliamentary standard of 120 grains.

Commencing with experiments Nos. 56 and 58; in No. 56 with a consumption of 119 grains, the illuminating power of the standard gas was represented as 15.3 candles; whilst in No. 58, with a consumption of 121.2 grains, it was 14.5 candles. The difference between these two experiments, made with candles which happened to be nearly within the Parliamentary standard, was .8 of a candle. In experiment No. 51, burning the normal standard quantity of 135 grains, the same gas was represented as being 15.48 candles; and in No. 61, consuming 134.4 grains, or .6 of a grain less, it was 16.28 candles, the difference being in this case also .8 of a candle. In experiment No. 60, with a consumption of 134.7 grains, or only .3 of a grain more, the gas was shown to be 18.18 candles, a difference of 2.70 candles in experiment No. 51, with a consumption of 129 grains of sperm, the gas had illuminating power 12.6 candles. In experiment No. 52, with a consumption of 145.2 grains, the gas appeared to be 12.6 candles. Experiment No. 52, with a consumption of 157.2 grains, gave the gas as 12.54 candles. The last three experiments were examples of candles consuming different quantities of sperm, yet giving practically the same amount of light; the correction of which to the Parliamentary standard of 120 grains created error. Experiments Nos. 57 and 54, each with the same consumption of 130.2 grains, showed the difference in the illuminating power of the gas to be 2.42 candles; the former representing it as 13.02, and the latter as 1544 candles. These were examples of candles burning the same quantity of sperm, yet giving a different amount of light. The greatest difference in the illuminating power of the "standard gas as shown throughout the forty-four experiments made upon this day, was 4.60 candles; being between experiment No. 51, with a consumption of 129 grains, giving an illuminating power of 13.58 candles, and experiment No. 60, consuming 134.7 grains, representing the gas to be 18.18 candles.

An examination of the various diagrams would demonstrate, that the differences in the candles might be classed under five heads; viz., First. Differences in the illuminating power of Parliamentary standard candles, burning at the rate of 120 grains per hour. Secondly. Differences in the illuminating power of normal standard candles, burning at the rate of 135 grains per hour. Thirdly. Candles with different rates of consumption, giving the same amount of light. Fourthly. Candles with the same rates of consumption, giving a different amount of light. And fifthly. Greatest differences of illuminating power, in the whole number of experiments when corrected to the Parliamentary standard.

From the tabulated results of three other sets of experiments, it appeared that, in the first, when the consumption of sperm varied from 109.2 to 134.4 grains, the greatest difference in the illuminating power of the gas, corrected to the Parliamentary standard, was 4.59 candles; in the second, when the consumption ranged from 120.9 to 130.8 grains, the difference in the illuminating power was 3.06 candles; while in the third, with a consumption of from 120 to 142.5 grains, the difference was 4.21 candles.

The second, third, and fourth series of experiments were made with candles obtained from one manufacturer only. As an example of the results arrived at by the second series, it was stated that with a consumption of sperm varying from 129.6 to 130.2 grains, the greatest difference in the illuminating power was 2.26 candles.

Third series of experiments was made for the purpose of ascertaining whether the French standard of comparison, when used at a photometer on the Bunsen principle, was more reliable than the candle. It was thus found, that when the lamps were allowed to burn without any regular system of trimming, the variations were about as great as those of the candles; but when the lamp was trimmed before the commencement of each experiment, the variation was about the same as with the best candles. It was probable that the result would have been better, if the time allowed for taking the observations had been fifteen minutes instead of ten minutes; for the lamp when filled weighed 10 lb., and the balance employed would not turn to less than a grain. Subsequent experiments corroborated this supposition. Of this series the examples selected showed, in one case, that the greatest difference in the illuminating power of the gas was 1.69 candle, with a consumption of sperm ranging between 136.5 and 124.5 grains. In another case the greatest difference in illuminating power, corrected to the standard consumption of 108 grains of oil in ten minutes, shown in the whole number of experiments, was 2.3 candles, when the time required for the consumption of 108 grains of oil by the lamps was respectively 9 minutes 39 seconds and 10 minutes $3\frac{1}{2}$ seconds.

For several years past the author had had in operation one of Mr. Lowe's jet photometers, for the purpose of indicating the illuminating power of the gas as it was being manufactured. As its apparent accuracy seemed to promise a more reliable means of determing the illuminating power of gas, it was decided to carry out a fourth series of experiments, with a view to discover the relation between the indications of this instrument and those of the French and English standards. At the "Cross" photometer, three consecutive experiments were made upon the quality of the gas, compared with four candles burning at the same time. The results of these twelve experiments were then averaged, and accepted as the illuminating power of the gas in each case. Another operator was at the same time engaged at the Dumas and Regnault photometer, and the average of these experiments was also taken as representing the illuminating power of the gas. Two of Mr. Lowe's jet photometers, fitted precisely alike, were in operation throughout these experiments; the orifice in each jet being of the same size, so that at any given pressure the height of the flame from each would be the same. The pressure at the point of ignition was regulated so as to give a flame exactly 7 in. in height and that pressure was duly recorded. The height of the flame at a pressure of .6 of an inch was also observed, as well as the time required for the issue of .1 of a cubic foot of gas under each of these pressures.

A diagram was prepared, showing the results of simultaneous experiments for ascertaining the illuminating power of different qualities, by two different systems, as at present existing, and by the proposed plan of testing by the jet. On this diagram a diagonal line had been drawn, which illustrated the theory of ascertaining the illuminating power of gas by means of the jet photometer, worked on the "Retrograde system," which might be thus stated: Maintaining a 7-in. flame from an orifice of certain fixed dimensions, the illuminating power of the gas was in direct proportion, inversely, as the pressure.

This diagonal line being considered as the "standard 7 in. flame," according to the theory just advanced, it was observed that the average results of twelve experiments very nearly coincided with the theory; and at pressures of .40, .51, .63, .64, and .68 of an inch this was especially the case. The highest and the lowest candle experiments were completely cut by the line, and the lamp experiments also tended generally to prove the theory.

Another diagram, representing the duration test corresponding with the retrograde scale, showed the time required for the issue of .1 of a cubic foot of gas, of a certain illuminating power, maintaining a 7 in. flame from the jet photometer. The use of the duration test was to check the working of the jet photometer, and to afford a means of discovering any irregularities that might occur in the apparatus. As an example of its use, it was seen by the retrograde scale that gas having an illuminating power of 14 candles gave a 7 in. flame at a pressure of .63 of an inch; and upon referring to the duration test it would be found that .1 of a cubic foot of gas of that illuminating power ought to maintain that flame for three minutes. Should there be any considerable deviation, it was an evidence of some derangement in the apparatus.

From these experiments the author believed it was evident that a more reliable method than that at present in use for determing the correct illuminating power of the gas supplied to the public was urgently needed; and he thought the following system would be found to give results approaching as nearly as practicable to a truthful estimate: Let the illuminating power of the gas be determined by the aid of the present recognized photometer, fitted with a Carcel lamp, burning oil of the same quality, and verified in the same manner as that adopted by the municipality of Paris as a standard; and let a sufficient number of experiments be made so as to cover the errors that were known to exist, and the average of these be compared with the illuminating power, as shown by the jet photometer and the duration test, and then the "mean of comparison" might be taken as the illuminating power of the gas.

ENAMELING AND POLISHING.

From "The Art of House Decoration," by Mr. Sutherland.

In speaking of enamel, it must be understood as polished paint on the surface of woodwork, such as doors, architraves, window shutters, etc., etc. Enameling and polishing is an art which requires the exercise of the greatest care and patience in its execution. A little carelessness or inattention at the finish may undo the work of days. The work will not bear any hurry, either in the material or labor, but must go through its regular course, have its proper time to harden between each coat and process; and the rubbing down must be patiently and gently done—heavy pressure will only defeat the end in view. Great care should be taken in the selection of the pumice-stone, both lump and ground, as the slightest particle of grit or hard pressure will scratch, and thus cause hours of labor to be thrown away.

In describing the material used for the purpose, we shall only describe that which we consider best suited for getting up the white or light-tinted enamel. There are several kinds of filling up color used and sold by the colorman, but most of them are of a dark color, not suited for light work, as they require so many coats of paint afterwards, to get a pure body of color, that it defeats its own object. In practice, we find it best to fill up from the first with the same tint of color we intend to finish with, thus forming a solid body of pure color, which will bear much rubbing down without being shady. For all dark grounds, which have to be finished a dark color, the black or dark filling is the best.

The tools and material required are as follows, viz:

1. White lead ground in turpentine, and best white lead in oil.
2. A clear, quick, and hard-drying varnish, such as best copal, Manders Brothers' white coburg, and white enamel varnish, etc., etc.
3. Ground and lump pumice-stone, or putty powder.
4. Rotten stone, ground in water or oil.
5. Some white felt, from a quarter to half an inch in thickness, and of the best quality.
6. Several flat wooden blocks, of various sizes and forms, suitable for getting into corners and mouldings; these must be covered with the felt on the side you intend to use.
7. Two or three bosses made with cotton wool, and covered with silk.
8. Sponge, and wash or chamois leather.

In order to simplify the description, we will take a plain panel to operate upon. If it is new, give it two coats of oil color, mixed in the ordinary way; now mix the white lead, ground in turps, with only a sufficient quantity of varnish to bind it with, thinning to a proper consistency with turps. It is as well to add a little of the ordinary white lead, ground in oil, as it helps to prevent cracking. Give the panel four or five coats of this mixture, leaving a sufficient interval between each coat to allow it to dry well. Let it stand for a few days, until it is hard enough to rub down. When it is ready, you may rub it down, first with a soft piece of lump pumice-stone and water, to take off the rough parts. Now use the felt and ground pumice-stone, and cut it down, working the hand in a circular form or manner. You will require to exercise much care and patience to rub it down to a level surface, and without scratches. When you have got it down level, if it is scratched or not sufficiently filled up, give it one or two more coats, laying it on as smoothly as you can, and rub down as before. If done properly, it will now be perfectly smooth, level, and free from scratches; wash well down, and be careful to clean off all grit or loose pumice-stone. Now mix flake white from the tube with the before-named varnish, till it is of the consistency of cream. Give one coat of this; when dry, give another, adding more varnish to it. Now, let this dry hard, the time for which will of course depend upon the drying qualities of the varnish; some will polish in eight or nine days, but it is much the best to let it stand as long as you possibly can, as the harder it is the brighter and more enduring will be the polish. When it is sufficiently hard, use the felt and very finely ground pumice-stone and water; with this cut down until you get it perfectly smooth; now let it stand for a couple of days to harden the surface, then take rotten stone, either in oil or water, use this with the felt for a little while, then put some upon the surface of the silk boss, and gently rub the panel with it, renewing the rotten stone as required. It is always better to rub in a circle than straight up and down, or across. Continue this until you have got it to a fine equal surface all over; it will begin to polish as you go on, but it will be a dull sort of polish. Clean off—if the rotten stone is in oil, clean off with dry flour; if in water, wash off with sponge and leather, taking care that you wash it perfectly clean, and do not scratch. You will now, after having washed your hands perfectly clean, use a clean damp chamois leather, holding it in the left hand, using the right to polish with, keeping it clean by frequently drawing it over the damp leather. Now use the ball of the right hand, press gently upon the panel, and draw your hand forward or towards you; if you do this properly, it will bring up a bright polish on the work, and every time you bring your hand forward a sharp shrill sound or whistle will be produced—if this is the case, you may be sure you are in the right path. Continue this until the whole surface is of one even bright polish. It will be some time, and will require much practice, before you will be able to do this in the best manner; but with perseverance and practice the difficulty will soon vanish. A soft smooth skin is best for polishing; if it is dry and hard it is apt to scratch. The latter part of these instructions referring to the polishing, will, of course, apply to polishing upon imitation woods and marbles, or on any polishing varnish, using the varnish pure, of course.

HEATING CARS BY STEAM.

Translated from "Polyt. Centralblatt."

Practical experiments on a large scale have been made in Germany on this subject, especially by the Brunswick Government R. R., the Prussian Eastern R. R., the Hanoverian Government R. R., and the Lower Silesian R. R.

On the Brunswick R. R. the steam was taken from the boiler of the locomotive, passing through a small cock of $1\frac{1}{4}$ in. interior diameter, into a large pipe of copper about 20 in. in diameter. Two such copper pipes were laid lengthwise below the floor of each passenger car, and connected by hose with the pipes of the adjacent cars. The pipes were covered by a grate along the walking floor. Under the seats they were covered by a wide box of sheet iron open in front so as to let the heat into the compartment and to protect the seats from the immediate radiation. These arrangements effected an increase of temperature in the cars of about 25° F., which is quite a favorable result.

On the Prussian Eastern R. R. the heating by steam of the passenger and baggage cars of the express trains was introduced in January, 1865. The steam is produced by a small tubular boiler standing in a compartment of the baggage car, and is carried along the train through a $1\frac{1}{4}$ in. pipe fixed to the lower part of the wagons. The maximum steam pressure is 30 lb. The pipes are joined by caoutchouc hose between the wagons. The heating of the compartments is effected by hollow cylinders connected below with the above described main pipe. The admission of the steam into the cylinders is regulated by cocks or valves from the outside of the wagons. It has not been found convenient to have this regulation done by the passengers from the inside of the compartments, and all the arrangements put in at first for this purpose had to be removed. The temperature in the wagons can easily be increased 50° F.

The steam pressure is very nearly the same over three wagon lengths, and consequently the heating power of the cylinders is about equal in the first three wagons. The above arrangements would therefore be sufficient for a larger number. No objections nor difficulties of any importance have been met with in using this system. The trains are running regularly over a distance of several hundred miles. The consumption of coal is about $1\frac{1}{2}$ lb. per English mile, thus causing but a very small expense.

The Hanoverian Government R. R. runs daily two mail trains, with steam heating, between Cologne and Berlin. The steam is generated in a small tubular boiler put up in a compartment of the baggage car. The heating pipes are laid through the cars lengthwise, their axis being about at the level of the floor. The wagons of one train contain four parallel pipes of wrought iron, those of the other train contain but two pipes of sheet iron. Both kinds of pipes have a diameter of $2\frac{7}{8}$ in. They are situated at a height of but one inch between the passenger seats, and located there immediately below the floor, so that a thin sheet of iron with which they are covered is even with the floor level. The emanation of the heat takes place principally below the seats, where the pipes are uncovered. This emanation can be lessened and regulated by valves so arranged as to cover the pipes more or less. The valves can be worked from the outside of the cars by the employees, as well as from the inside by the passengers. On the first trial of these heating arrangements the temperature of the air was raised from 41° to about 60° F. The consumption of coal amounted to 25 lb. per hour, during which time 175 lb. of water were used. The whole arrangement has been found good and convenient. Further experience will show if it will prove sufficiently effective in severe frost.

The steam heating machinery actually in course of construction on the Lower Silesian railroad is similar in principle to that of the Hanoverian railroad. The details are not yet known. S.

IRON AND STEEL NOTES.

Silicon and Sulphur in Cast Iron.—The following practical remarks, on the making of pig iron, are culled by the "American Exchange and Review," chiefly from the new edition of Kerl's Metallurgy, by Dr. Crookes:

When casting pig iron in cast-iron moulds (chills), it will be found that the least silicon is contained in the lower part of the pig, on the other hand most of the combined carbon; whilst the upper part of the pig is richer in silicon and other substances which may separate. In such cases most of the manganese will also be found in the upper part. Upon casting pig iron in moist sand, the lower part of the pig is less modified. It is therefore advisable to cast good forge pigs in cast-iron moulds forming thin plates.

The following plans may be adopted for producing pig iron poor in silicon: Employing low temperatures and carbonizing the iron as perfectly as possible; or if a higher temperature is required, employing admixtures of lime to render basic the sufficiently aluminous mixtures from which silicon is reduced with more difficulty than from silicious mixtures poor in alumina; and, finally, adding manganiferous fluxes. The latter fluxes partly render the mixture easier to fuse, and the manganese combines with the silicon and separates on the surface of the liquid iron. According to Lohage, manganese, as well as aluminium, also facilitates the separation of silicon at the smelting of cast steel.

Good gray foundry pig iron may contain as much as two per cent of silicon; if containing a larger amount, it is harder and less strong, but it may be improved by remelting, when part of the silicon will be separated. Such iron, containing an excess of silicon, is fine grained, of light color, has but little lustre, and solidifies quickly.

Forge pig iron suffers more loss by scorification the more silicon it contains; it may, nevertheless, be more advantageous to produce pig iron rich in silicon and poor in sulphur, when treating impure ores at a high temperature, than by employing a low temperature to produce iron poorer in silicon and richer in sulphur, as silicon may be more perfectly separated than sulphur. The state of combination of the silicon essentially influences the behavior of the iron at its conversion into malleable iron.

Lohage suggests that gray forge iron should contain at least two per cent of silicon in order to form a slag which shall thus preserve the iron from further oxidation; and as the silicon first oxidizes, time is allowed for the separation of sulphur and phosphorus. Forge iron containing about 1.5 per cent of silicon is not usually desirable.

The higher sulphides lose in the upper parts of the furnace part of their sulphur, with iron, if iron is present in a reduced state, and if the temperature is sufficiently high. The sulphur in pig iron does not seem to be always combined with iron, but sometimes with silicon. Schafhäutl mentions an instance, that at the tapping of pig iron in the Tividale iron works, near Dudley, sulphide of silicon, of the composition Si^2S^3, analogous to the oxide of silicon, was separated in the form of a whitish-yellow, spongy, earthy substance. The sulphur is frequently not divided uniformly in the pig iron, and in the common pigs collects more in the upper part than in the lower part.

Additions of lime whilst applying higher temperatures, thus forming sulphide of calcium, which has the property of dissolving other metallic sulphides (sulphides of iron, manganese, etc.), and of sending them into the slag. This re-agent is more effective if the sulphur is contained less in the ore than in the gangue, fuel and fluxes, as, in the latter case, sulphide of iron is not at first formed, but sulphide of calcium, which directly enters the slag. Slags produced at Hattingen, from iron pyrites of the coal measures, contained from four to six and a half per cent of sulphide of calcium.

The Chemistry of the Blast Furnace.—The following are the principal points in the recent paper of Mr. I. Lowthian Bell, read before the Chemical Society:

Scheerer, Tunner and Ebelman, who have made experiments on the subject, have laid down with apparent precision the parts of the furnace, and the temperatures at which the different stages of the manufacture of iron—the reduction of the oxide and the union of the iron with carbon—take place. The former is commonly supposed to happen at a very considerable temperature, while the latter is commonly believed to take place in the hottest part of the furnace. Mr. Bell has arrived at conclusions altogether different. His results go to prove that the deoxidation of the ore takes place at a comparatively low temperature, and that the carburization is effected long before the metal is liquified and separated from the slag.

Mr. Bell dissents from Scheerer's representation of the various changes that go on in the blast-furnace, as taking place in zones; and he seems to attach much more significance to the term used by Scheerer than need be. The "Mining Journal" says: We are disposed to consider that the zones spoken of by Scheerer, where the reduction, carburation and fusion of the metal take place, are so far real that they are at least relatively different parts of the blast furnace, not, indeed, definable by absolute lines, but still in a certain degree distinct. That in certain furnaces the zone of reduction should tend to assume the form of an acute cone, rather than a layer with horizontal boundaries, is quite conceivable; but whatever be the configuration of its vertical or horizontal areas, it is not the less distinct and different from the zones of fusion, carburation and calcination, where processes of a different nature are in progress.

The attainable economy of fuel in smelting iron is another point to which Mr. Bell directed attention. When it is considered that something like two and one-half tons of coal are consumed in producing one ton of pig iron, even when hot blast is used; and that to effect the chemical change of smelting, only eight hundred weight of coal are needed, still leaving one-half of the heating power of that coal unapplied, and available for further use, the great importance of devising means of economizing fuel in this operation will be obvious. More than four-fifths of the coal consumed in producing pig iron, is consumed in raising the temperature of the charge to effect fusion, and that is done under the most disadvantageous circumstances as regards production of heat.

The gases escaping from the throat of a blast furnace have not only a large amount of unused heat-generating power, but they have also a temperature and reducing power capable of preparing ore for the subsequent processes of the blast furnace. In the Cleveland district economy in this direction has been carried to a considerable extent, by increasing the height of the furnace, and thus taking off the gas at a lower temperature than is sometimes the case elsewhere. But it is from the higher heating of the blast that greater economy is now to be looked for. The idea that hot blast deteriorates the quality of iron is now pretty well exploded, and there is no reason that some advance should not be made in effecting economy of fuel by this means.

Accurate Rolling-Mill Machinery.—At length the managers of our finished ironworks are arriving at the just conclusion that most of the stoppages by the breakdown of machinery result from inaccurate adjustment and rude construction. Consequently gearing of absolute accuracy, and of greater strength with less material, is now in demand, and the works where these are produced are busy in that especial department. There can be no doubt whatever that a vast economy will result from the use of such castings, even as there is much saving yet to be effected in the engine department of our mills and forges. So soon as the iron trade generally shall see that it is not economy, but, on the contrary, extravagance, to cast their wheel gearing at home upon the old models, and shall go to our best machinists for what they require, and pay a very much larger sum for it, weight per weight, then we shall have less cumbersome apparatus, worked by engines which do not consume four times as much steam as with different gearing would be necessary. The losses which have resulted in the past year from stoppages by the breaking down of the unwieldly machinery too frequently to be observed thundering in our ironworks. are, to our knowledge in certain cases, somewhat startling. They are the more so because at neighboring works, where a heavier first cost was not shunned, and where, as a consequence, light, easy and almost silent working machinery is in operation, the stoppages have been of an insignificant character.

The foregoing is from the correspondence of "The Engineer." The same lesson has been learned by our progressive iron workers in America—and the result is the establishment of special manufactories of rolling mill machinery, such as that of Matthews & Moore, in Philadelphia, where trains of rolls are fitted up with the accuracy and solidity that characterize marine engines.

The Radcliffe Process.—An invention has recently been patented in England, by which it is claimed that masses of iron or steel may be produced of sufficient size to form girder, rail, shaft, armor plate, &c., which will be homogeneous throughout, in so far that they will be without any weld, in the ordinary sense of the term. Some years since, the welding of two or more puddled balls into one, under a steam hammer, was practised in Wales, and more recently in America, for instance at the Albany Iron Works; and by this means large masses were produced, but the process was not satisfactory, because the surfaces of the balls became oxidized, and good union could not always be secured between them in consequence. In the Radcliffe process, a number of puddled balls are worked together under a heavy steam hammer; but in the process here alluded to the puddled balls are welded together in a furnace, when the iron is surrounded by a neutral flame, and the oxidation of the iron is thus prevented. It is contended, also, that the cost of producing rails, armor plates, &c., by this process will be much less than by the ordinary methods. It is difficult to explain the arrangements connected with the furnace, without the aid of diagrams, but we may briefly state that a hydraulic anvil is made to work horizontally through an opening in one side of the furnace, and on the other a steam hammer is made to move in a similar manner. Thus mechanical appliances can be brought to bear upon the manipulation of a large or small quantity of iron. By an arrangement of rolls in front of the furnace, it is proposed to roll the iron into shape without reheating. The use of the hammer entering the furnace, to perform the welding in a neutral flame, was long since patented in America, by Alonzo Hitchcock, of New York.

Improvement in Iron Castings.—Messrs. Munro and Adamson, of Glasgow, have patented some improvment in the mode of manufacturing articles now made of malleable or wrought-iron, steel, or cast-iron from re-melted pigs, foundry scraps, or direct from the blast-furnace. Chills of the shape required for the articles to be produced are provided, and molten iron is run into them. As soon as solidified, and for the purpose of making the material very hard and dense, the casting may be taken from the chills and cooled in water or otherwise, or it may be allowed to remain in the chill for a longer period, or the chills may be surrounded with or cooled by water. In place of forming the chill castings of absolutely crude iron, the iron before being cast may be partly refined by blowing atmospheric air into its mass, or by placing compounds of oxygen into the vessel or furnace wherein it is refined. The chilled castings are afterwards annealed or tempered, thus producing a material possessing many of the properties of wrought, forged, or malleable iron, but avoiding the costly manufactureof iron now in use.—*Mining Journal.*

If we had not tried a part of this invention without success,we might believe it new and useful.—Ed. *V. N's Mag.*

Cryolite in iron Furnaces.—The "Colliery Guardian" contains the following paragraph:

"An invention patented by Messrs. James Bowron and George Lunge, of England, consists of mixing fluoride of calcium, the same being obtained artificially or in the form of a native fluor spar, or the mineral known as "cryolite," either in a state of fine division or otherwise, with the materials used in blast furnaces, for the purpose of removing, wholly, or in part, the phosphorus contained in the pig iron to be obtained therefrom. The invention further consists in using fluoride of calcium in puddling and other furnaces, to aid in the manufacture of wrought-iron and steel by the removal of the phosphorus contained therein. The phosphates resulting from such treatment may be utilized as manure."

We hear that the "Stevens Flux," notorious in this country for its brave promises and halting performances in the extraction of "more gold than could be found by ordinary assay," has already found a sphere of real usefulness in the metallurgy of iron—though we are not prepared to say that its application is novel or that its employment at the price charged for it will prove economical. As we have often said, whatever good qualities the Stevens Flux possesses are probably shared by native fluor spar; and now, for the consolation of Col. Stevens, we will reverse the case, and say that whatever advantages the above patent of Bowron and Lunge presents, are probably shared by his Flux. What's sauce for the goose is sauce for the gander.—*American Journal of Mining.*

Coating Iron with Brass.—A new process has just been patented of coating iron with brass, copper, silver and other metals, which bids fair to work almost a revolution in some of the trades of Birmingham. One method heretofore employed is veneering—if that term be applicable to metal—but the expense and difficulty attending it have been an objection to it from the first. Electro-plating by various processes has been attended with much greater success, but even this coating is not so durable as could be desired. What has long been wanted is a method of coating iron with brass or silver, as readily as it is now coated with tin, and so as to render it equally durable. This has been at length successfully accomplished by a Wolverhampton patentee with remarkable success. The process adopted is that of immersion, but of course the details of the invention are for the present kept secret. I have seen, says the correspondent of "The Engineer," some sheets of iron which have been coated with copper on this principle, quite equal, for all practical purposes, to sheets of copper. They will bear stamping into all imaginable shapes, and even burnishing, without removing the copper coat, the latter having to all appearance eaten its way into the inferior metal. Coated iron on this principle will supersede brass and copper to an enormous extent, for while it will be equally serviceable, it will be 40 per cent lower in price.

The Durometer.—An instrument for testing the hardness of metals, by drilling, has been invented, says the "Builder," by M Behrens, an engineer of Tarbes. in France. It is said that it has been thoroughly tried, and that many French contracts for rails now contain a condition that they are to be tested by this apparatus. It consists of an upright cast iron standard bolted down upon a bedplate, and provided with a table for supporting the rail or other article to be tested. The spindle of the drilling tool is capable of being raised and lowered in its bearings by turning a handle for that purpose, and the drill is held down to its mark by a weight fitted to the upper end of the drilling spindle. Its rotary motion is derived, through a pair of mitre wheels, from a driving shaft carrying the usual fast and loose pulleys. This shaft has a worm upon it which moves a train of mechanism, in connection with a signal gong, for the purpose of indicating the number of revolutions made by the drill. The apparatus is exceedingly compact. Its use by French manufacturers has led to a gradual increase in the hardness of the rails they produce.

Estimating the Impurities in Iron.—Gintl gives a very easy method of determining the impurities in cast iron. It is applied by him to the estimation of the sulphur contained in the iron, but, as will be seen, it is available for the separation and determination of most of the usual impurities. The iron is reduced to as minute a state of division as possible, and is then treated with a strong solution of perchloride of iron, as nearly neutral as possible. The mixture is kept heated for ten or twelve hours, at the end of which time almost all the iron will be found to have dissolved, leaving, as a residue, the carbon, sulphur, phosphorus and silicium, together with the little iron left undissolved. This residue has only to be well washed, oxidized and dissolved, and the sulphur estimated as sulphate of baryta. The exact plan directed by the author is to introduce the residue and filter into a porcelain crucible, having, at the bottom, three parts of nitrate of potash and one part of hydrate of potash; heat to fusion, dissolve and precipitate with chloride of barium. The phosphorus and silica will be contained in the same solution, and can be determined separately. —*Mechanics' Magazine.*

A New Fact in the Behaviour of Iron.—Mr. Gore has noticed a new fact in the behaviour of iron under the influence of heat and of strain. A strained iron wire was heated to rednesss by a current of voltaic electricity, and then, the current being discontinued, was allowed to cool. It was observed that there arrived a moment in the process of cooling at which the wire suddenly elongated, and then gradually shortened, until it became perfectly cold, remaining, however, permanently elongated. No other metal besides iron exhibited this peculiarity, which Mr Gore attributes to a momentary molecular change, and he points out that this change would probably happen in large masses of wrought-iron, and would come into operation in various cases where those matters are subjected to the conjoint influence of heat and strain, as in various engineering operations, the destructions of buildings by fire, and other cases. The phenomenon deserves a further investigation, since every fact relating to iron is of importance to us.—*Mechanic's Magazine.*

Effect of Phosphorus on Iron and Steel.—With respect to the influence of phosphorus and slag in iron, Professor Styffe has a theory that the diffusion of slag through iron containing phosphorus, has a beneficial influence in counteracting the injurious effect of the phosphorus. The results of experiments as to the influence of this material upon the tenacity of iron, agree pretty closely with those of Karsten and others. The author says: "The tensile strength of iron is not sensibly impaired by the presence even of 0.2 or 0.3 per cent of phosphorus, provided the metal has not been strongly heated after having undergone the operation of rolling or extension by other manipulation." He even maintains that the presence of even a considerable quantity of slag or cinder in iron impregnated with phosphorus is beneficial, by preventing the largely crystalline structure which would otherwise result from the presence of that element. With respect to the influence of phosphorus in steel, the author, on the contrary, confirms the opinion that it is injurious, rather than beneficial, and says that he knows no authenticated instance in which the proportion of phosphorus has been higher than 0.4 per cent in what has been considered as good steel.

Tungsten Steel.—It is many years since Mr. Mushet proposed to alloy iron with tungsten in the formation of steel. We reported a year or two ago that Mr. Leguen, in France, had made experiments with the same alloy, employing iron converted by Bessemer's process. Then he used a common gray pig, not fit for conversion, but produced, nevertheless, an alloy of very good quality. Lately, he has continued his experiments, now employing good white cast iron, and has produced a steel of excellent quality. A portion of the iron is first alloyed with one-tenth wolfram, in a cupola furnace, and is added to the rest in the converter. The conversion is carried further than usual, so that the carbon is reduced to one-half the ordinary proportion. The steel so produced is soft, but very tough, and tempers remarkably well. Mr. Leguen mentions that it will be found extremely useful for machines, some parts of which require to be tempered, while others are kept soft. The objection brought against this alloy is that it is expensive, but the amount of tungsten employed by Mr. Leguen is so small—only 0.55 per cent—that it can make but a very small addition to the cost of the steel.—*Mechanic's Magazine.*

Testing Boiler-plates by the Saxby Method.—During the past year the Saxby method of detecting flaws in iron, by the deflection of a magnetic needle, has been experimented with in England with especial reference to the detection of flaws in boiler-plates. In one of these trials a piece of partly used plate, that had successfully withstood all the Admiralty tests, was shown by the new method to possess a weak point; the existence of the defect and the efficacy of the method being subsequently proved by a re-examination of the plate by mechanical means. So successful have been the trials thus far made, that Mr. Saxby is led to claim for his method the attribute of infallibility.—*American Artizan.*

To renovate old Files and Rasps.—A file or rasp worn smooth is immersed for a time in a mixture of one part nitric acid, three parts oil of vitriol and seven parts water. The time it must be allowed to remain in this acid bath depends upon the quality of the metal. A very hard steel will require a longer immersion than a soft fine-grained metal. The tool is then well rinsed in water, and then (to ensure the perfect removal of the acid) in milk of lime. It is afterwards to be dried, and the lime is brushed away. When new files are made by this plan, they require a little additional treatment to protect them while in stock. After they have been carefully dried, and the lime has been brushed away, they are to be brushed over with a mixture of olive oil and turpentine, and, lastly, well rubbed with very fine charcoal powder. Any one would imagine that the acid, acting equally on all parts, would simply dissolve away some of the metal, and leave the file as smooth and useless as before. But such, we are assured, is not the case. Files may be renovated over and over again, and are always as good as new.—*Mechanic's Magazine.*

Casting a 70-Ton Anvil Block.—At the new Steelworks at Landon recently, a 70-ton block for a steam hammer, was successfully cast by Mr. Williams of St. Helen's Works Swansea. Two cupolas were specially erected at a suitable distance to enable the metal to run directly into the mould. Operations commenced at an early hour, and by a quarter to 10 a. m. the charges began to follow each other at regular intervals at three-quarters of an hour up to 9 p. m., at which time the block containing seventy tons of iron was finished. This is the largest casting ever made in Wales. The dimensions are 11 ft. 6 in. by 9 ft. 6 in. at base, and 7 ft. 6 in. high, and it will occupy from two to three weeks to cool sufficiently to allow it to be reversed, it having been cast base uppermost. Trunions joining part of the casting are so placed that it will simply be turned upon its own axes.

The Siemens-Martin Process in France.—The Terrenoire Ironworks have now four Martin furnaces in operation. Ere now this process has been carried on, introducing scraps of Bessemer steel into cast iron. It is necessary, of course, that this cast iron be entirely free from phosphorus. Some trials have been made in the use of worn out rails instead of Bessemer steel, but that has been a complete failure. The rails were exceedingly brittle, and the railway companies have forbidden the mixture of old iron rails with the Bessemer steel used in the Martin process. This difficulty might be avoided with good iron obtained from a cast iron free from phosphorus, but the price of the steel would be greatly increased. This process will be very useful to the makers of Bessemer steel, enabling them to get rid of their scrap.—*Correspondence of The Engineer.*

RAILWAY NOTES.

Freight Cars with Changeable Gauge.—A new through freight line between Boston and Chicago, called the "National Despatch Line," are now running a through line of changeable gauge of freight cars, between those cities, passing over the Boston and Lowell and Nashua, Concord, Northern (N. H.), Vermont Central, Montreal and Vermont Junction, Grand Trunk and Michigan Central Railways, comprising the 4 ft., $8\frac{1}{2}$ in., and 5 ft. 6 in. gauges. One hundred of those cars are now in use on the line; a part of which have been running since the 1st of January very successfully and satisfactorily, and it is intended immediately to increase the number of cars to five hundred, and afterwards to further increase the stock as the business requires.

ENGLISH LOCOMOTIVE EXPENSES.

COMPARATIVE STATEMENT OF HALF-YEARLY MILEAGE, LOCOMOTIVE EXPENDITURE, AND TRAFFIC RECEIPTS OF VARIOUS ENGLISH LINES.

Half-year ending January, 1869.

NOTE.—We gave last month a table showing the total expenses of the principal British lines. The following table, from "Engineering," gives the details of locomotive expenses on some of these lines.

	Great Western. Passengers.	Great Western. Goods.	Great Western. Total.	London and North-Western. Passengers.	London and North-Western. Goods.	London and North-Western. Total.	North-Eastern. Passengers.	North-Eastern. Goods.	North-Eastern. Total.	Midland. Passengers.	Midland. Goods.	Midland. Total.	Great Northern. Passengers.	Great Northern. Goods.	Great Northern. Total.
Train Mileage:															
Train, miles run	3,807,542	3,738,243	7,545,785	5,707,650	5,754,220	11,461,870	....	....	Estimated. 7,260,245	....	....	Estimated. 7,547,242	1,942,009	2,639,179	4,581,188
Engine, miles run	3,927,095	4,564,520	8,491,615												

	Great Western. Cost. £ s. d.	Great Western. Average cost per train mile. d.	London and North-Western. Cost. £ s. d.	London and North-Western. Average cost per train mile. d.	North-Eastern. Cost. £ s. d.	North-Eastern. Average cost per train mile. d.	Midland. Cost. £ s. d.	Midland. Average cost per train mile. d.	Great Northern. Cost. £ s. d.	Great Northern. Average cost per train mile. d.
Locomotive Expenses:										
Salaries, office expenses and general superintendence	6,640 17 8	.21	12,140 11 1	.25	5,566 10 6	.18	5,249 18 2	.16	3,026 7 5	.15
Running Expenses:										
Wages connected with the working of engines	68,240 3 2	2.17	114,055 14 5	2.38	75,831 14 4	2.49	70,116 14 4	2.22	42,188 15 5	2.21
Coal and coke	47,165 5 0	1.50	80,610 0 3	1.68	80,244 5 9	2.65	53,639 18 9	1.70	39,678 12 10	2.08
Water	6,447 19 0	.20	3,894 14 5	.08	6,118 19 11	.22	5,794 0 8	.18	3,111 18 7	.16
Oil, tallow, and other stores	6,921 13 8	.22	12,686 13 5	.26	11,964 16 6	.36	13,111 15 4	.41	6,738 10 6	.35
	128,775 0 10	4.09	211,247 2 6	4.42	174,159 16 6	5.75	142,662 9 1	4.53	91,717 17 4	4.80
Repairs and Renewals of Engines, Tools, &c:										
Wages	61,356 11 11	1.95	82,143 8 7	1.72	57,595 1 6	1.90	40,361 8 2	1.28	37,291 7 4	1.95
Materials	53,740 16 3	1.70	75,473 5 3	1.58	48,671 13 6	1.60	64,196 17 0	2.04	32,622 3 7	1.70
	115,097 8 2	3.66	157,616 13 10	3.30	106,266 15 0	3.51	104,558 5 2	3.32	69,913 10 11	3.66
Repairs of workshops, sheds, and engine turntables	1,793 7 4	.05	4,056 11 7	.08	....	....	1,351 10 10	.04		
Gas	1,213 2 4	.04	....	....	4,801 19 10	.15	929 14 10	.03	2,114 14 5	.11
Total: Gross expenses	253,519 16 4	8.06	....	....	290,795 1 10	9.61	254,751 18 1	8.10	166,722 10 1	8.73
Less for power supplied	8,112 0 11	....	....	....	9,338 7 9	....	10,095 18 7	....	5,354 19 10	
Total: Net expenses	245,407 15 5	7.98	385,060 19 0	8.06	281,456 14 1	9.61	244,665 19 6	8.10	161,417 10 3	9.18
Percentage on traffic receipts	12.12		11.22		14.12		14.55		14.19	

	Great Western. Passengers.	Great Western. Goods.	Great Western. Total.	London and North-Western. Passengers.	London and North-Western. Goods	London and North-Western. Total.	North-Eastern. Passengers.	North-Eastern. Goods.	North-Eastern. Total.	Midland. Passengers.	Midland. Goods.	Midland. Total	Great Northern. Passengers.	Great Northern. Goods.	Great Northern. Total.
Traffic Receipts:															
Train miles	3,696,731	3,684,773	7,381,504	5,707,650	5,754,220	11,461,870	2,701,083	4,325,946	7,027,020	3,159,971	4,088,133	7,248,104	1,842,926	2,503,842	4,346,768

	Great Western. Amount of receipts. £ s. d.	Great Western. Pr. train mile. s. d.	London and North-Western. Amount of receipts. £ s. d.	London and North-Western. Per train mile. s. d.	North-Eastern. Amount of receipts. £ s. d.	North-Eastern. Pr. train mile. s. d.	Midland. Amount of receipts. £ s. d.	Midland. Pr. train mile s. d.	Great Northern. Amount of receipts. £ s. d.	Great Northern. Pr. train mile. d.
Passengers	978,473 12 2	5 3.52	1,543,524 19 11	5 4.90	636,701 3 3	4 8.56	609,125 13 10	3 10.26	492,701 10 11	5 4.16
Goods	1,045,892 9 5	5 8.12	1,886,997 2 3	6 6.70	1,355,250 18 2	6 3.18	1,072,035 18 9	5 2.93	644,181 3 10	5 1.74
Total	2,024,366 1 7	5 5.81	3,430,522 2 2	5 11.83	1,991,952 1 5	5 8.03	1,681,161 12 7	4 7.66	1,136,882 14 9	5 2.77

Four Coupled Express Engine—Paris and Lyons Railway.—This type of engine may thus be generally described: Outside horizontal cylinder 17.33 in. in diameter by 25.6 in. stroke, four driving wheels 6 ft. 6.2 in. in diameter and 6 ft. 10 in. apart, and a pair of leading wheels 3 ft. 11.66 in. in diameter and 6 ft. 2.4 in. forward of front drivers. The driving wheels have only two springs, the axles being connected by compensating beams. The following particulars (and also engravings) appear in "The Engineer" of May 21, 1869:

	ft.	in.
Length fire grate	4	4
Width do	3	$3\frac{1}{2}$
Surface of grate in square feet	15	0
Height inside copper fire-box near the tubes	5	3
Height near the door	4	$10\frac{1}{2}$
Length at the top	4	2
Length at the bottom	4	4
Width	3	$3\frac{1}{2}$
Thickness of side plate	0	$0\frac{1}{2}$
Thickness of door plate	0	$3\frac{3}{5}$
Thickness of copper tube plate at the top	0	1
Thickness of copper tube plate at the bottom	0	$0\frac{1}{2}$
Number tubes	164	
Outside diameter	0	2
Thickness	0	$0\frac{1}{12}$
Length between plates	16	$3\frac{1}{2}$
Length outside fire-box	4	11
Width at the top	4	$2\frac{1}{5}$
Width at the bottom	3	$10\frac{1}{5}$
Thickness	0	$0\frac{1}{2}$
Outside diameter small plates of shell,	4	$1\frac{1}{5}$
Length of shell	16	$0\frac{2}{5}$
Height of the centre above the rails	6	$4\frac{1}{2}$
Steam pressure	120 lb.	
Diameter of each of the two safety valves	0	$4\frac{2}{5}$
Heating surface fire-box, square feet	80	
do tubes, square feet	1260	
do total	1340	
Inside diameter chimney	1	$4\frac{1}{2}$
Height above the rail	14	4
Transverse distance frames	4	$0\frac{2}{5}$
Thickness do	0	1
Total length of the engine	29	$7\frac{3}{5}$
Diameter of leading wheels	3	$11\frac{2}{3}$
Diameter of driving and trailing wheels	6	$6\frac{1}{5}$
Distance from leading to driving wheels	6	$2\frac{2}{5}$
Distance from driving to trailing wheels	6	10
Total wheel base	13	$0\frac{2}{5}$
Transverse distance between wheels	4	$5\frac{1}{2}$
Transverse distance between centers of journals	3	$8\frac{1}{3}$
Length of journals of leading wheels	0	$9\frac{5}{6}$
Diameter of do do do	0	$6\frac{1}{3}$
Length of journals of driving and trailing wheels	0	$9\frac{5}{6}$
Diameter of journals of driving and trailing wheels	0	$7\frac{1}{3}$
Number of plates in springs of driving wheels	16	
Thickness	0	$0\frac{3}{5}$
Width	0	$3\frac{1}{2}$
Length driving spring plates	3	9
Number of plates in springs of leading wheels	11	
Thickness	0	$0\frac{1}{2}$
Width	0	$3\frac{1}{2}$
Length	2	10
Camber	0	$3\frac{1}{6}$
Diameter of cylinders	1	$5\frac{1}{3}$
Stroke	2	$1\frac{3}{5}$
Length of connecting rod	5	11
Transverse distance between centers of cylinders	6	$2\frac{4}{5}$
Angle of advance of eccentrics	30 deg.	
Throw of eccentrics	0	$2\frac{2}{5}$
Stroke of slide valves in full gear	0	$4\frac{2}{3}$
Inside lap of slide valves	0	$0\frac{1}{50}$
Outside lap of slide valves	0	$1\frac{1}{5}$
Length of steam ports	0	$11\frac{4}{5}$
Width of steam ports	0	$1\frac{2}{5}$
Width of exhaust ports	0	$2\frac{3}{5}$
Weight of empty engine	30 tons 8 cwt.	
Length of connecting rod	8	$4\frac{2}{3}$
Diameter of connecting rod	0	$4\frac{2}{3}$
Length of coupling rod on driving wheels	0	$3\frac{1}{2}$
Diameter of coupling rod on driving wheels	0	$4\frac{1}{3}$
Length of coupling rod on trailing wheels	0	$3\frac{1}{2}$
Diameter of coupling rod on trailing wheels	0	$3\frac{1}{2}$

Distribution of Weight in Working Order.

	tons.	cwt.
Leading wheels	9	9
Driving wheels	12	11
Trailing wheels	12	5
Total	34	

These engines run at an average speed of forty-five miles an hour, traversing inclines of 1 in 200 with trains weighing 115 tons, exclusive of the tender, which weighs twenty-three tons in working order. They are very steady, and the company have been so well satisfied with their working, that after a first supply of fifteen engines, fifteen more have been ordered.

The Railroads of the United States.—From a comprehensive abstract in the New York "Times," of Mr. Henry V. Poor's new work on Railroads, we compile the following statistics: There were in operation in all the States, on the 1st day of January, 1869, 42,255 miles of line, the cost of which, at $44,000 per mile, equaled $1,800,000,000. The total amount of net tonnage transported over them for the year equaled 75,000,000 tons, having a value of $10,472,250,000—a sum equaling six times their cost, and more than four times greater than the whole amount of the national debt!

The construction of these works upon a grand scale commenced with the discovery of gold in California, in 1848. The number of miles in operation in the country, on the 1st day of January of that year, was 5,599. The mileage annually constructed from the opening of the first section (23 miles) of the Baltimore and Ohio Railroad in 1830, to 1847 inclusive, equaled 311 miles. The yearly average opened from 1848 to 1860, inclusive, equaled 1,925 miles—the aggregate opened in this period being 25,037 miles. During the war the number of miles built equaled 3,273, or 818 miles annually. Since 1864, 8,347 miles have been opened, or 2,086 miles annually. The number of miles opened the past year equaled 2,979 miles.

There are in progress fully 15,000 miles of line, of which at least 5,000 miles will be opened the present year.

The ratio of mileage of these works to our total population is as 1 of the former to 876 of the latter. The ration in the New England States is as 1 to 846 ; in the Middle, 1 to 1,037; in the Southern, 1 to 969; and in the Western, 1 to 731. The State of New Hampshire has 1 mile of railroad to 500 inhabitauts; the State of Nebraska, 1 to 163; and the State of Florida, 1 to 343.

The State having the largest proportionate mileage is Massachusetts, which has 1 mile of road to 5.47 square miles of area. The State of Ohio has 1 mile of line to 11.76 square miles. A ratio similar to that for Massachusetts would give to the whole country 600,000 miles of line. One similar to that for Ohio, 300,000 miles. The total amount of net tonnage transported over all the railroads of the United States for the year 1851, did not exceed 5,500,000 tons. The rate of increase from that year to the close of 1867, in which year 75,000,000 of tons were transported, exceeded 1,300 per cent. The tonnage traffic of all the roads in the country in 1858 equaled 18,750,000 tons. The increase in the decade commencing with this year consequently equaled 300 per cent traffic.

The value of the tonnage for 1867 is estimated to equal that of the several classes of freight transported on the Erie canal for that year, (the value o. which is carefully ascertained,) or $139.63 per tonf The aggregate value of the tonnage of all the roads equaled, consequently, the enormous sum of $10,472,250,000. At a similar estimate the value of the tonnage transported in 1851 equaled $765,236,725; in 1858, $3,096,762,500. The total increase in value of the tonnage transported in 1867 over that transported in 1851 equaled $9,707,013,275, and $7,375,487,500 over that transported in 1858.

Our railroads transport, on an average, 2,000 tons to the mile. The tonnage of the railroads of Massachusetts, for 1867, equaled 5,394,137 tons, or 3,853 tons to the mile. That of the railroads of New York equaled 10,343,681 tons, or 3,501 tons to the mile ; that of the railroads of Pennsylvania equaled 35,383,370 tons, or 7,864 tons to the mile. The tonnage borne on the railroads of those States having a mileage of 8,750 miles equaled 51,121,140 tons, or 5,826 to the mile. The tounage of most of the great roads far exceeded the estimate. The aggregate amount transported could not have been less than 100,000,000 tons.

Over ordinary highways wheat will bear transportation only 250 miles; Indian corn only 125 miles. Upon railroads these, the most valuable of our cereals, will bear transportation 3,200 and 1,600 miles, respectively. The area of a circle drawn upon a radius of 125 miles equals 49,077 square miles; that of a circle drawn upon a radius of 1,600 miles, 8,042,496 square miles.

The total earnings of all the roads in the United States in 1851 equaled $39,406,358. The receipts from freight and passengers were almost exactly balanced. The earnings from all sources in 1867 were $400,000,000, of which $280,000,000 were received from freight, and $120,000,000 from passengers. The rapid increase of earnings from freight is a most favorable feature. The earnings of the English railways in 1851 were $73,000,000, of which $35,000,000 were from freight, and $38,000,000 were from passengers. In 1867 their total earnings were $190,000,000, of which $105,000,000 were from freight, and $85,000,000 from passengers. The ratio, in this country, of earnings from freight to earnings from passengers is as 2.2 to 1; in England is a little over 1.1 to 1.

The earnings of American roads are more than twice greater than those of England. The railroad mileage of that country in 1867 was 14,247; in the United States, 39,276. The cost of the former, equaled very nearly $2,500,000,000, that of the railroads of the United States, for the same year, $1,700,000,000. The earnings of the English roads, upon their cost, equaled 7.86 per cent ; those of the United States very nearly 25 per cent. The English roads, however, have a great advantage over our own in operating expenses, their net earnings, as a rule, fully equaling one-half of the gross receipts. In this country the net cannot be estimated at over 30 per cent of the receipts. The following statement presents in detail the various items entering into the cost of operating the railways of the two countries—the railroads of the State of New York being taken as representing those of our own :

Items of cost per train, mileage of running trains upon the railroads of New York and Great Britain for 1867 *:*

	New York. Cents.	Gt.Britain. Cents.
Maintenance of way, including iron	49.50	12.70
Repairs of engines and materials	17.35	6 45
Repairs of cars	21.18	6.74
Wages of engineers and firemen	8.36	3.00
Fuel	21.60	3.42
Local taxes	5.50	2.20
All other charges	42.62	26.86
Total	166.00	61.37

The preceding statement shows the cost per mile of operating the railroads of the State of New York to be two and a half times greater than that of operating the railways of Great Britain. The earnings of our roads, however, per mile run are nearly twice greater—the average earnings of the former being $1 25 per mile ; of the latter about $2 30 per mile. The most startling difference in the items of cost is in the matter of fuel ; the cost of the same in this country being 21.60 per mile, in England 3.42 per mile.

In 1880 the population of the United States will equal 50,000,000. Its railroad mileage will equal 70,000 miles. At the estimate of only 2,000 tons to the mile their aggregate tonnage will equal 140,000,000 tons, having a value of more than $20,000,000,000, while our population is increasing at the rate of 1,200,000 annually.

THE NEW YORK CENTRAL Company recently paid a million of dollars for four acres of land for a terminus in New York.

Locomotives of the Paris, Sceaux and Limours Railway.—This railway has curves of 82 ft. radius. The engines have four driving wheels, but the wheels on the opposite sides are independent of each other, and are driven by two cylinders for the right and two for the left pair of wheels. The driving tyres are 12 in. wide, without flanges. The leading and trailing wheels are flanged, and are loose on the axle, (which is free to turn raidally to the curve), and they are fitted with "guiding bogies" which have wheels lying nearly horizontally and bearing against the inner edge of the rails. The following are particulars of the engines, from "Engineering," January 29, 1869, in which paper the machinery is illustrated.

	Engines with four cylinders, built in 1855, and subsequently altered.	Engines at Ivry in 1867.
Cylinders:	ft. in.	ft. in.
Diameter	11	16
Stroke	20	24
Distances between centers		9 4
Total width of engine		11
Wheels:		
Diameter of leading and trailing wheels	3 8	3 5
Diameter of coupled wheels	5	5
Length of wheel base	17	16 6
Boiler:		
Diameter of barrel		4 6
Number of tubes	134	201
Diameter		$1\frac{7}{8}$
Length	11	12 6
Height of top of firebox above grate		4 3
Length of grate		3 9
Width		4
Area	10 sq.	15 sq.
Heating surface; tubes (outside)	744	2,234 sq. ft.
Heating surface; firebox	56	80 sq. ft.
Total	800	1,314
Weight in working order:	tons.	tons.
On leading wheels	8	10.3
On front pair of coupled wheels	12	12.0
On hind pair of coupled wheels	12	12.0
On trailing wheels	8	8.7
Total weight	40	43.0
Weight available for adhesion	24	24
Capacity of water tanks	880 gallons	
Quantity of coal carried		$2\frac{1}{2}$ tons

One of the engines was subjected to some trials with a train of forty carriages. In passing round the terminal curve of 25 metres (82 ft.) radius, this train covered three-quarters of a circle; seven carriages projecting beyond the engine and half the train proceeding in the opposite direction to the latter. In another trial a train of thirty-seven carriages carrying 1,200 soldiers, run from Bourg-la-Reine to Orsay round the terminal circle at the latter place, ascended the incline of 1 in 180, and returned to the point of departure in 43 minutes.—The distance run was 28 kilometres, or about $17\frac{1}{2}$ miles, so that the average speed was about $24\frac{1}{2}$ miles per hour. The reverse curves at Palaiseau (328 ft. radius) was traversed at 25 miles per hour, and the terminal circle at Orsay at a speed of from 7 to 8 miles per hour. The total mileage run during the year is 236,000 kilometres, or 160,000 miles. The cost of maintenance of the carriage stock is 0.3 francs per kilometre, or 4.8d. per mile, and the cost for lubrication 0.18 francs per kilometre, or 2.88d. per mile. The cost of traction varies from 0.8 to 0.9 francs per kilometre, or from 12.8d. to 14.4d. per mile.

This system of locomotives and cars (similarly constructed) is that of M. Arnoux, and it has been in regular and successful operation for some fifteen years.

Steel v. "Best" Iron Rails.—In the autumn of 1867, Captain Tyler and Mr. C. W. Eborall visited the Grand Trunk Railway of Canada and reported in great detail upon its financial, structural, and mechanical condition. Upon the question of rails, Captain Tyler observed in his report:

The difficulty of obtaining durable rails of iron has of late years been very generally felt, and has induced an outcry for steel rails in quarters where it would not otherwise have been heard. Much trouble has resulted, and much expense been incurred, for the want of rails of good quality in England, and still more in the United States, and in Canada. . . . In Canada, as elsewhere, after the failure, from lamination, of steel-headed rails, it has been considered that it would be better economy in the end to lay down steel rails than to continue to use iron with such lamentable results. . . . But I have, after careful inspection and inquiry, become convinced that iron rails of appropriate form, of suitable and reasonably good quality, and of sufficient hardness in the heads, may be made to last on most parts of the main line for fifteen years, and on the average of the Grand Trunk Railway for very much more. . . . The chance of procuring new rails of superior quality lies probably in insisting on a longer term of guarantee for the rails supplied, in employing the most reliable manufacturers and in paying a price commensurate with the value of the article. No manufacturer need have any fear of prolonging the guarantee to seven or even ten years if he only furnish a suitable rail.

The practical result of Captain Tyler's recommendations is not at all, however, what was wished, and it proves that the "outcry" for steel rails, to which he refers, was more than well founded. In the company's last report the directors remark:

The directors regret that the rails sent out from this country in 1867, purchased from the best makers, are not giving satisfaction. The directors took every precaution to secure the best rails which could be made, and exacted guarantees from the makers which they are putting in force. The small quantity of steel rails sent out in 1865, although placed on a part of the line where the traffic is very heavy, show no signs of giving way.

The engineers of the company, Messrs. E. P. Hannaford and J. F. Barnard, in their report to the directors, state that,

The rails latterly re-rolled in the United States and Toronto have proved superior to new rails imported from England. This is a very important fact, as we are of opinion new rails made from ores direct from the mine should be better in every respect than rails made from old material, which, from successive re-heating and the mixture of different qualities of iron, must of necessity prove inferior to rails made from new iron properly manufactured. In former years imported English rails have stood the test of our climate with success, although of lighter section than those now laid; and we are unable to understand why English rails cannot now be made to stand, and must press upon you the urgent necessity of insisting upon the works employed to make rails for us in England turning them out better than those imported during the past two years. The complaint we now make about the quality of English imported rails is almost universal among all railway companies in the United States and Canada. The one-third of a mile of Bessemer steel rails laid in 1865, near Kingston, continue to show no failure; not one rail has been replaced, or likely to be for years, although the traffic at this place is more than ordinary. Some of the best iron rails laid at the same time and locality as the steel have had to be removed, and others, considerably worn, must come out this year. The general condition of the track and works, as compared with former years, is satisfactory, but we would again call your earnest attention to the question of the quality of imported rails, as, until we get English rails to stand, the annual cost of renewals of iron must of necessity continue heavy, and during the present year we must incur a large outlay, owing to the bad quality of most of the English rails, and their need of being replaced before they have lasted even the lowest average.—*Engineering.*

Duties on Passengers and Tonnage.—Mr. Ashbel Welch, General President of the Camden & Amboy & New Jersey Railroad Companies, states a very large case in a very few words, in Appendix G. of the late report of the said companies:

When these companies were incorporated, during the infancy and inexperience of railroad legislation, it was unfortunately provided that they should be taxed by transit duties on passengers and tonnage. This amounted to ten cents per passenger, and fifteen cents per ton between the Delaware and Raritan, and twenty-seven cents per ton, and not quite fifteen cents per passenger, between the Delaware and Jersey city. While only passengers and high-classed goods were carried by rail, this tax was not so severely felt; but when, contrary to the contemplation of the law, low-classed tonnage sought the rail route, its embarrassing and paralyzing effect was found to be greater than any one, not called upon to deal with the subject, can readily understand.

Where there is no tax on tonnage, it is the true interest of railroad companies to make a moderate profit per ton on a large tonnage. rather than a larger profit on small tonnage; for the increase of tonnage and consequent increase of intercourse increases their other business. But a tax on tonnage prohibits, or at least limits, this policy. For example: if the profit on one ton of railroad iron, between Trenton and Jersey city, is fifty cents, without transit duty, then, with the transit duty of twenty-seven cents, it becomes twenty-three cents net to the companies. But if, by reduction of rates, the quantity is increased tenfold, as in this case is probable (the cost in consequence being also reduced), and if the profit is then twenty-five cents per ton, without transit duty, the aggregate profit is $2.50, or five times as much as on the one ton; but, with the transit duty of twenty-seven cents per ton, there ensues a net loss of twenty cents on the ten tons.—So such a reduction, as is highly advantageous, without the transit duty, would be impossible with it. The transit duties on tonnage were, therefore, sometimes prohibitory—always restrictive in their operation—and cheap transportation was impossible. The odium of this fell mainly on the companies.—They were taxed excessively by an unexpected operation of the law, and punished by the public for being so taxed.

Efforts, heretofore made to cure the evil, have failed. Public men have feared to touch the subject, as the action required might endanger the revenues of the State. At last the companies appealed to the people, and found them in advance of their representatives. It was not supposed possible to do more at first than to modify the transit duties on the lower grades of property. But with the unexpected support, and even pressure, of the people, and under the enlightened advice of the chief magistrate of the State, the Legislature wisely abolished all transit duties, and substituted other taxation.

The new law, in effect, commutes the annual State taxation of the companies at that of 1868, which was not quite $300,000. The annual increase of transit duties paid the State for the last eight years has been between $15,000 and $16,000. The new connections of the companies' works, with the roads leading south and west, the pressure upon them of cheap property, at low freights, the diversion (consequent on the consolidation of the companies' interest) of traffic to the Jersey city route, where the taxation was highest, tend greatly to accelerate the rate of increase of transit duty that would have been paid, in addition to the acceleration due to the general increase and returning prosperity of the country. Large as the fixed amount to be paid is, it is much smaller than the transit duty would have become in a very short time.

But the greatest advantage of this change of taxation is, that it gives the companies the free use of their own works—removes the dam which has so much obstructed their traffic—allows them to increase their business without paying enormously for the privilege. The excessive disparity heretofore existing between the taxation of these companies and that of other railroad companies in the State, though not removed by this law, is prevented from increasing. The greatest burden was not the amount actually paid, but the amount that would have been paid if the roads had been worked to the best advantage.

Borsig's Express Locomotives—These engines are used for what is termed "fast" passenger traffic on the Rhenish railway. They have four coupled wheels 5 ft. 6 in. in diameter. The leading wheels are 3 ft. 4 in. in diameter, and the total wheel base is 13 ft. 6 in., the distance between the centers of the coupled axles being 8 ft. 2 in. The trailing axle is placed below the firebox, the firegrate being inclined; and the driving and trailing springs are connected by compensating beams. The front ends of the two leading springs are also connected by a transverse compensating beam, which oscillates on a center below the front end of the boiler; and it follows from this arrangement that the engine is virtually carried on three points. All Borsig's engines are supported on the springs in this way, and the same or equivalent arrangements are adopted on almost all German locomotives.

The cylinders, which are 16 in. in diameter by 22 in. stroke, are outside; and so also is the valve gear, which is of the "straight link" kind. One peculiar feature in the boiler of the engine we are describing is the great height given to the firebox casing, a feature which has been extensively adopted by Borsig, both for the purpose of giving additional steam room, and adding weight to the engine at the hind end. In addition to the raised firebox casing the boiler is also provided with a dome $24\frac{1}{2}$ in. in diameter and 3 ft. 5 in. high at the leading end. The front and back of the firebox casing above the firebox, and the smokebox tubeplate above the level of the tubes, are stayed by plates on edge secured to them by strong T and angle irons. The crown of the firebox is supported by being connected to transverse girders or stays, which extend across the firebox casing from side to side, and which thus serve as ties between these sides in addition to supporting the firebox crown.

The barrel contains 171 tubes, $1\frac{7}{8}$ in. in diameter, and 11 ft. $1\frac{1}{2}$ in. long, these tubes being of iron with copper ends. The heating surface of the firebox is 69 square feet, and that of the tubes (external) 930 square feet, making in all a heating surface of 999 square feet. The weight of the engine is 30 tons, empty, and 33 tons 14 cwt. when in working order, this latter weight being divided as follows:

	tons.	cwt.
On leading wheels................	11	14
On driving wheels................	11	6
On trailing wheels................	11	14
Total	33	14

The engine is provided with a six-wheeled tender, weighing, empty, $11\frac{1}{2}$ tons. In the year 1867, Borsig supplied ten engines, of the class we have described, at the price of £2,650 per engine and tender, and last December he received a further order for twelve such locomotives at the price of £2,533 per engine and tender. This type of engine is illustrated in "Engineering," May 21, 1867.

Mr. Scott Russell and Railway Ferries.—A little more knowledge of the facts, if not a reasonable amount of courtesy, would have saved some of our American newspapers, technical and otherwise, the discreditable mistake of abusing Mr. Scott Russell about what he has said and done regarding the introduction of railway ferries. The animus of the prime mover in this crusade against Mr. Russell may be observed in the wild way it goes about abusing that gentleman—for instance—by saying that the paddle engines of the Great Eastern were a failure, the fact being that they were a great success.

It seems to "rile" the American eagle beyond all endurance, that Mr. Russell designed and executed a ship to ferry railway trains across Lake Constance, and then described it in a paper before the Institution of Naval Architects, and urged a similar means of transit between England and France. And why? Because the same thing was done in America before! To be sure Mr. Russell said in his paper, "I must say that it is not me the English people have to thank for having made this experiment for them." He described a work of his own, and as his own, when a similar work had been done in America *before*. That is his offense. Suppose he had built a North river steamer or a twin screw, and had then urged their farther adoption and magnified the details of his own work without claiming credit for the general idea. Should we have gone mad over that? The railway ferry is as notoriously of American origin as the North river steamer or the twin screw. Or must Mr. Scott Russell begin by praising American genius every time he speaks of his constructions of the American type?

Mr. Russell *has*, on several occasions, described the Havre de Grace railway ferry as a brilliant feature of Amcrican practice, and he has always been the admirer and advocate of the many good features in American marine and mechanical construction. A native yankee, "with the stars and stripes grown onto his back," could not have rendered more frequent and hearty, and possibly not more graceful, tribute to the American practice than Mr. Scott Russell has rendered, in his many speeches and writings, for the last fifteen years. In fact, the greater part of the literature concerning the American steamboat practice has been made by Mr. Scott Russell and his son. For an American engineer to abuse Mr. Scott Russell is simply disgraceful.

Apparatus for Testing Rails.—Mr. Charles T. Liernur, formerly of Mobile, and now resident abroad, patented some nine years since, an apparatus of which the following is the specification:

"The object of my invention is to construct an apparatus in which the rail is subjected to a course of trials similar in its results to actual usage when laid upon the road. For this purpose I lay a circular track composed of 3, 4, or more rails (or pieces of rails), making a circle of from 20 to 30 or more feet in diameter. On this track I place a car supported by four, six, eight, or more wheels, all the axles of which point towards the center of the circular track. The wheels to be of the size, pattern and make as actually are to be used upon the road for which the rails are to be tested, and the car to be loaded with the weight per wheel equal to the greatest load they will have to sustain when in use upon the road. The vertical shaft to be well braced, and to be strongly attached to the car, so that when a rotary motion is given to the former, this motion will be participated in by the latter, a beveled cog-wheel being placed at the top or bottom of the shaft for the purpose of revolving it by means of a stationary steam engine placed near by.

"What is claimed as the invention is a railway car revolving by means of a center-shaft, and supported by four, eight, or more wheels, the axles of which point towards said shaft, and running said car upon a circular track of railway rails for the purpose of submitting both rails and wheels to a test of usage."

This plan has recently been proposed in England by other parties, and it is to be hoped that the experiment will be carried out.

Rolling Stock of the Central Pacific.—This Company has now running 150 locomotives. Besides these there are seven partially set up in San Francisco. There are several more contracted for, yet to arrive. The engines, in running order, are from eleven different makers, the largest number from one firm being 47 from McKay & Aldus, 28 from the Danforth Locomotive Company, 24 from the Schenectady, 10 from the Rhode Island, etc., only one being from Booth & Co., San Francisco. Two have drivers 3 ft. 9 in. diameter;

about twenty have six drivers 4 ft. diameter; twenty-five have six drivers 4 ft. 6 in. diameter; forty have four drivers ranging from 5 ft. 6 in. to 5 ft. diameter; sixty have four 5 feet drivers each; and two have four 5 ft. 6 in. drivers. Excepting two small locomotives, with two drivers each and 11 in. cylinders, 15-in. stroke, the locomotives run 16, 17 and 18-in. cylinders and 22 and 24-in. stroke. The engines under contract have six drivers, 5 feet diameter, 18-inch cylinder, and 24-in. stroke.

The Company owns 1,400 platform cars, nearly all of which have been made at Sacramento. The total number of box cars on the road is 360, with an increase at the rate of 30 a week. Of composite baggage, mail and express cars, there are 17 in work, and others constructing. Of hand cars and track cars and section cars, there are 123, and more making. The passenger cars are not very numerous; but besides ten in use, four are making in the shops and there are ten contracted for in the East. The Company also own a handsome family carriage. The sleeping cars will come from the east, and will be kept on those sections of road where night traveling is done.—*American Railway Times.*

Tie-spotting Machine.—This device, built by Mr. Jauriet, of the Chicago Burlington and Quincy shops at Aurora, is thus described by the "Chicago Railway Review:" Our readers are aware that rails are generally laid level upon the ties, with the result of bringing the whole weight of the car upon the inside of the rail and the inside of the inclined rolling surface of the wheel. Mr. Jauriet conceived the idea of laying the rail so as to incline inwards on the same level as the surface of the wheel. The old hand process of doing this, with adze, is slow, unequal, and costs more than it comes to. The tie-spotting machine—attached to a car and transported from place to place on the line—may be generally described as consisting of two vertical shafts, with knives attached, to which the ties are brought by means of a chain-feed. The knives are adjustable, so as to "spot" at an angle, or in the ordinary manner. The machine is operated by the engine attached; and requires, besides the engineer, six men to operate it, who do the work of from fifteen to twenty. A recent experiment resulted in the spotting of seventy-six ties in fifteen minutes.

Chicago, Burlington and Quincy Shops at Aurora.—We condense the following from the "Chicago Railway Review:" The present old works at Aurora are to be enlarged as follows: Car shop, 400 by 100 ft., two stories; setting up shop, 200 by 90 ft.; car machine shop, 100 by 90 ft.; car smith shop (nearly done), 200 by 90 ft.; paint shop, 200 by 90 ft.; drying kilns, lumber sheds, a tin and brass shop and a fire proof engine and boiler house. The old engine house (40 stalls) will remain, and another will be added. The present machine shop is 185 by 50 ft., stocked with Bement's and with Sellers' tools, among which are 26 lathes, 8 planers, and 7 drilling and boring machines. The present smith shop is 80 by 50 ft., and has a 4,000 lb. Bement-Davy hammer. The boiler shop is 60 by 50 ft. There are also a brass foundry, an oil house, and a rail repairing shop. The locomotive superintendent is Mr. C. F. Jauriet, and the superintendent of the car department Mr. W. W. Wilcox.

Chicago and Alton Shops at Bloomington.—The original shops at this place were burned in 1867. Temporary works were improvised within the old walls. The new works are more than half completed, and will have cost about five hundred thousand dollars. They are built of rough dressed stone, and have slate roofs on iron trusses. Gas lighting and steam heating are extended to every part.

The two engine houses (one completed) are 230 ft. in diameter, for 28 locomotives each. The machine shop will be 260 by 100 ft. with a wing 80 by 45 ft., and engine and boiler house attached. There is to be a transfer table outside of this building.—The smith shop is to be 200 by 100 ft.; the boiler shop 180 by 60 ft.; coal shed 125 by 40 ft.; iron house 80 by 50 ft.; foundry 210 by 60 ft., and cleaning room attached, 50 by 45 ft.

The car shop is 263 by 80 ft.; the car machine shop 200 by 75 ft. (2 stories), with outside transfer table and attached engine house; the paint shop 172 by 75 ft. A two story office and store building, 120 by 60 ft., is centrally situated.

The superintendent of machinery is Mr. J. A. Jackman; the superintendent of the car shops is Mr. Rufus Reniff.

Communication between Passenger and Guard to be enforced in England.—The Act for the Regulation of Railways, passed last session, provided that "after the 1st of April, 1869, every company shall provide and maintain in working order, in every train worked by it which carries passengers and travels more than twenty miles without stopping, such efficient means of communication between the passengers and the servants of the company in charge of the train, as the Board of Trade may approve. If any company make default in complying with this section, it shall be liable to a penalty not exceeding £10 for each case of default. Any passenger who makes use of the said means of communication without reasonable and sufficient cause, shall be liable to a penalty not exceeding £5." The Board of Trade have extended the time in order to afford further opportunity for further testing the merits of the numerous plans submitted to the companies.

Steel Rails.—Steel rails, it is reported, are to be laid on the entire length of the railroad from Paris to Marseilles. The change from iron to steel will require 137,000 tons of steel. From experiment made by the company, it has been calculated that in the vicinity of the stations iron rails will not last over eight or ten years. The steel rails, it is believed, will last thirty or forty years. The bridges are to be constructed of steel as soon as iron ores suited to the manufacture can be obtained in sufficient quantity.

The Erie Railway Company have completed 17,000 tons of steel rail on their road—not a broken rail since. They have purchased the New Jersey Iron Works and those at Elmira, and are now turning out about 400 tons of steel rail every month. Within a year the whole line will be relaid.—*American Journal of Mining.*

Locomotive Boiler Explosions.—No fewer than fourteen locomotives have exploded within the seven months ending June 1st, in the United States, killing twenty-nine persons outright and severely wounding a much greater number.

THE BROAD GAUGE, as regards the midland districts of England, is now a thing of the past, the Great Western Railway Company having ceased to run any broad gauge passenger trains between London and Birmingham, Wolverhampton and Liverpool. Already, too, on the branch between Reading and Basingstoke, the third rail has been removed, thus converting that line from a mixed gauge into an entirely narrow gauge line, and connecting the Great Western system with the London and South-Western Railway and the south of England. In addition to this, the whole of the broad gauge lines north of Oxford will immediately be taken up, removing in the midland counties the last trace of the system of one of the two great rival engineers, whose plans were so long hotly contested, and celebrated as "the battle of the gauges."

ANOTHER BRIDGE ACROSS THE MERSEY.—Messrs. William Low and George Thomas, civil engineers, have submitted to the Mersey Dock and Harbour Board a letter and plans, illustrating their scheme of crossing the Mersey by means of a railway suspension bridge between Liverpool and Birkenhead. It will consist of three spans, the center one 1,800 ft. in length, and the others 960 ft. each, and will be 140 ft. above high water mark. The bridge would unite the various railway lines in Lancashire and Cheshire. It will be under two miles long, and the total cost is estimated at £1,750,000. This would be the sort of thing to try our engineering mettle before we venture to bridge the Irish and British channels.

NEW INDIAN RAILWAY.—Operations in connection with the laying out of a new and important line of railway communication have just been commenced by a staff of British civil engineers. The line is designed to connect Carwar, on the Malabar coast, and the cotton districts of Hooblee and Dhawar, with the probability of its being carried through into the Madras Presidency. The line is to be designated "The Southern Mahratta and Mysore Railway." There will be formidable difficulties to contend with in "carrying the line up the densely-jungled ghaut," with an elevation of some 1,500 ft. The undertaking is to be carried out under the direct orders of the government.

THE ST. GOTHARD RAILWAY SCHEME.—It is rumored that, in addition to a subvention of 50,000,000f. to this scheme, Prussia is now ready to renounce her real or imaginary rights over the Swiss territory. The project has been well received in Switzerland, the Northern and North-Eastern Railways each contributing 9,000,000f., whilst the various German cantons will, it is expected, vote considerable sums in addition to the Federal subsidy.

THE CHANNEL BRIDGE.—M. Boutet's system of excessively long spans (3,282 yards) is being tested by *models* of one hundredth size, and upon the success of one, the "Journal Officiel de l'Empire Francais" says: "The project of a bridge over the straits makes each day further progress." * * * "The problem is resolved that bridges and viaducts of *every size* can be constructed in a single arch without piers from bank to bank!"

THE CREUSOT works have secured a fresh order for locomotives (fifty-five altogether) on Russian account.

LEGISLATION TO AID RAILWAYS.—During the five weeks' session of Congress, thirty-one bills were introduced in the Senate alone contemplating grants of public lands, bonds, or credit, or all three, to railway projects. The land grants proposed vary from one to eighty thousand sections in each case, and amount in the aggregate to about two hundred million acres.

RAILROADS VS. STEAMBOATS.—Drawing-room cars and steel rails are beginning to furnish those solid comforts which pleasure travelers have heretofore considered peculiar to steamboats. The roominess, upholstery and decoration of steamboats are all that could be desired, but there should be better ventilaton of dining-saloons, less early blowing off of steam, and more polite attendance.

FAST RUNNING.—Trains on the fast railway line between Liverpool and London can now be driven at the rate of fifty miles an hour, and the whole distance (200 miles) accomplished in four hours. There is no stopping for water, this being scooped up from troughs between the tracks while the train is running at full speed.

CONNECTICUT RIVER BRIDGE AT MIDDLETOWN.—The Keystone Bridge Company, of Pittsburgh, have contracted to build the new wrought iron bridge on the Boston, Hartford & Erie road at Middletown, Ct. It will be of 1,200 feet span, and will cost $176,000.

NEW BOOKS.

GEOLOGY OF NEW JERSEY. By authority of the Legislature. GEO. H. COOK, Geologist. 8vo. 899 pp., with portfolio of eight large maps. Published by the Board of Managers, 1868. New York: D. Van Nostrand.

This substantial volume gives the final report of the geological survey of New Jersey. The first survey of this State was made by Prof. Henry D. Rogers, the report of which was published in 1840. A subsequent survey was conducted by Dr. William Kitchell, geologist, and Prof. George H. Cook, assistant, during the years 1854, 1855 and 1856. But before the survey was completed, the failure of legislative appropriation compelled its close. The present survey was authorized in 1864, under Dr. Cook as geologist, and the result of the four years' labor and investigation of him and his assistant is given in this volume.

It consists of two distinct portions; the first, comprising about one-third of the volume, is a strictly scientific exposition of the geological formations found in the State. The work, in this department, has been mainly expended in extending the geological systems of New York and Pennsylvania into the corresponding formations of New Jersey. This has not been entirely without difficulties, because not a few unsolved mysteries had been bequeathed by the geologists of the neighboring States. The task, however, has been thoroughly done, and much light has been thrown on the intricate questions of fossil and lithological geology. In the appendix to the volume will be found some valuable catalogues bearing on these scientific inquiries.

The second portion of this work will be found to the general reader more interesting, and to those interested in developing the resources of the State, of the greatest value. It treats of the economical products of the State with a fullness and thoroughness which will be found equaled in no similar work. In this respect Dr. Cook and the managers of this survey deserve the thanks of the people of New Jersey and of her neighbors. To the agricultural public this complete exposition of the extent, the value and the characteristics of those marvelous beds of marl, will be most acceptable. Literally this fertilizer has for New Jersey turned the wilderness into a fruitful field. Many, for the first time, will find in this work the first systematic and satisfactory explanation of its value as a fertilizer. To those interested in mining, the chapters on the iron regions will be found especially acceptable. A special map is devoted to this region, and the location and direction of all the known iron beds are here laid out. It will surprise not a few to learn, from this work, that New Jersey, although standing twentieth in the scale of population among the States of the Union, furnishes one-eighth of all the iron, and in manufacturing iron stands fifth.

In other economic products New Jersey is unusually rich. One-half of all the zinc product of the United States is derived from her mines. Her clay beds furnish a vast variety of clay, from that suited for manufacturing common brick to that which will produce the finest porcelain. She has peat beds which will furnish a bountiful supply of fuel when the coal beds of Pennsylvania are exhausted. She has immense beds of sand, which is in demand for the manufacture of glass, fire-brick, and concrete stone. Her manufacturing interests are scarcely less important than her agricultural. Newark has grown to be a city of 120,000 inhabitants, and is the third city of the Union in the value of its manufactured products.

Situated as New Jersey is, between the two greatest markets of the United States, she can never fail to be one of the most important sections of the country. Cheapness of transportation, the certainty of a market even for the most perishable products, the fertility of her soil, the industry, thrift and intelligence of her inhabitants, ensure for New Jersey a rapid development of her resources, and an unexampled career of prosperity. To this rapid development this valuable report of Dr. Cook cannot fail largely to contribute. The Legislature has wisely decided to continue the survey under the same admirable management for an additional period.

Modern Practice of the Electric Telegraph.—A Handbook for Electricians and Operators. By Frank L. Pope. New York: Russell Brothers, Publishers, 28, 30, and 32 Center street.

During the quarter of a century which has elapsed since the introduction of the electric telegraph in the United States, those engaged in its service have been almost entirely dependent upon verbal instruction, and long practical experience, for a thorough technical knowledge of their profession. The works heretofore published on the subject have been of a popular rather than of a scientific or practical character, or else of so elementary a nature as to be of little service except to very inexperienced students.

The work before us, though very concise, is a treatise suitable for the practical electrician and telegraph operator; but it will also be found serviceable to the student as well as to the more advanced electrician. Its author, who, though a young man, is a telegrapher of many years' experience, and has a thorough scientific knowledge of all that relates to the telegraph, goes very fully into the various branches of the subject—batteries, magnets, circuits, and insulation. The book contains a very complete description of the Morse or American telegraph system, explains the testing of telegraph lines, gives notes on telegraphic construction, and hints to learners, and concludes with very copious notes on various minor details.—*American Artizan.*

Lehrbuch der gesammten Tunnel-baukunst. Von Franz Rziha. Ernst and Korn, Berlin, 1868.

The fourth part of the second volume of this magnificent work of Rziha's, which we have noticed at length in past pages of the "Practical Mechanics' Journal," has appeared; and all we need say of it is that it fully sustains the reputation of the preceding parts.

In the present part the Belgian. German and Austrian systems (for they all differ a good deal) of tunneling are fully described and critically compared. This is followed by an elaborate comparative critique and estimate of costs, of timber-frame tunneling, with a chapter or two on the methods of lining with masonry under diverse conditions; and these lead on to the commencing chapters, in which the author is about to describe his own peculiar system and construction of cast and wrought-iron moveable framing for tunneling without timber, of which we before now gave a tolerably complete sketch to our readers.—*Practical Mechanics' Journal.*

Leitfaden zur Bergbaukunde &c. Von Bergrath H. Loptner. Bearb. u. herausg. von A. Serlo: Erste Liefrg.

We may fitly place this work after that of Rziha, for it treats of a very analogous subject. Tunneling and shaft-sinking for railways have much in common, and have in fact borrowed much in practice from level and adit driving and shaft-sinking for coal and other mining. These last are the operations here treated of, and treated of with the ability we are prepared to expect from the reputation of Bergrath Lottner, well known in Germany for his grand maps and sections of the coal formations of Westphalia, &c., and as a Professor of Mining in the Royal Mining Academy of Berlin. The present part treats mainly of sinking and driving through various "ground," and includes all the new machinery for boring and holing each, and the new and old explosive agents. The work will be completed in three large parts (or volumes, we may almost call them,) with many illustrations by excellent woodcuts; and the successive parts will embrace every head of subject belonging to the miner's art, so far as the entering the ground, securing it, and keeping the shafts, &c., level water and foul air free, are concerned. It excludes, as belonging to metallurgy proper, the treatment of the material, of whatever sort, extracted by means of the excavations made.—*Practical Mechanics' Journal.*

The Manufacturer and Builder. May, 1869: New York. Western & Co., 37 Park row.

This monthly journal contains 78 columns of interesting matter and numerous engravings for 15 cents—a marvelously cheap technical publication. The articles in the May issue for instance, are 60 in number, 10 of which are illustrated; the following are of special interest: The Telephone, Boiler Explosions, Beton building, Hydraulic Mortar, Hydrogenium, Magenta (analine color), Church Architecture, Interior Decoration. A journal giving so much information at such a price, deserves success.

Woodward's National Architect; containing 1,000 original Designs. Plans and Details to Working Scale, for the Practical Construction of Dwelling Houses for the Country, Suburb and Village. With full and complete sets of specifications and an estimate of the cost of each design. By George E. Woodward, Architect, Author of "Woodward's Country Homes," "Woodward's Cottages and Farm-houses," etc., etc., and Edward G. Thompson, Architect. New York: George E. Woodward, 191 Broadway.

High rents and close quarters are driving the inhabitants of cities like New York into the country with unprecedented rapidity, and, thanks to our railroads, it is now nearly as easy to live twenty miles out of town as to live in the upper part of the city. The loss of time is about as great in the one case as in the other, while the advantages of a real country residence are so great, especially to children, that no sensible man will stay in the city if he can possibly make his escape. To those who contemplate taking a part in this exodus the work we have just recited will prove invaluable. It is filled with chaste designs for conveniently arranged dwellings.

The plan of the work embraces designs for houses of moderate valuations, estimated at New York prices as a basis, with such detail prices as will enable one to ascertain the cost, in his own locality, by comparison with the different rates of prices that always exist in different sections of the country.—The forms of specifications given are such that they may be adapted to any of the designs, so that full and final estimates can be obtained from local builders. To builders and architects residing in the country this work must prove invaluable.—*Manufacturer and Builder.*

Zell's Popular Encyclopedia and Universal Dictionary. Philadelphia: T. Ellwood Zell. Part XI. 1869.

It is not many years since a comparatively small cyclopedia sufficed to contain exhaustive articles on almost every branch of human knowledge. How has all this changed! Some of our modern cyclopedias which deal with a single science contain as much matter as the first edition of the "Encyclopedia Britannica." At the same time, the tendency is toward condensation; and in the popular encyclopedias of to-day, we find dismissed in a single line a subject which a few years ago would have been expanded into a page. This holds particularly in relation to the well-known and deservedly popular cyclopedia published by the Messrs. Chambers, of Edinburgh. The same feature is prominent in the cyclopedia before us. In short, it combines the characters proper to both a cyclopedia and a dictionary. Thus we find not only such nouns as *ambition, ambler, ambling,* but adjectives like *ambitious* and adverbs like *amblingly.* On the other hand, such articles as ammonia are extended far beyond the limits of a mere definition, and present all the really valuable facts that are of interest to popular readers. We see that the editor has wisely avoided the futile attempt to supply the wants of professional men, who must, in all cases, rely either upon their own knowledge, or upon the assistance of purely technical works. We refer to such subjects as alcoholometry, alkalimetry, etc. In most popular cyclopedias, these purely technical departments of the chemist's art are either treated at an unreasonable length or described so superficially as to lead to error. The editor of "Zell's Cyclopedia" has avoided both these dilemmas. The publishers engage that the cost of the work, when completed, shall not exceed $25, and we know of no means of procuring the same amount of valuable information at such an easy rate.—*Manufacturer and Builder.*

Smoking Fires, their Cause and Cure. By the Rev. Alexander Colvin Ainslie, M.A., Vicar of Corfe, Somerset. For sale by Van Nostrand.

"Where there is smoke there is fire," says the adage, but where there is smoke there is too often no light—to point out its cause or remedy—if the smoke be that of a house chimney. The puffing back, or even in some cases streaming back of smoke into a room, can be avoided or cured, and ought never to happen, though the fact is that there is scarcely a building even of the first class in which some of the chimneys do not smoke. That it is due in great part to the practical ignorance of first principles on the part of architects and housebuilders, and to the carelessness of both to almost everything but to getting "the job done and paid for," is certain.

Parson Ainslie has written by far the best treatise on the subject that has been produced. "The ascent of heated air and smoke is governed by certain known laws," he says in his introduction; "and the object of the following pages is to explain those laws as concisely as possible, and to point out the causes which most commonly modify or interfere with their action, and produce results apparently contradicting scientific theory." He does so in a brief and lucid manner, and then applies these laws to nearly all the examples of smoky chimneys occurring or likely to occur in practice, and deduces rules for guidance that even the least philosophical of bricklayers can scarce fail to comprehend and readily be guided by.—*Practical Mechanics' Journ.*

Annual of Scientific Discovery, etc., for 1869. Edited by Samuel Kneeland, A. M., M.D., etc. 12mo, pp. 377. Boston: 1869. Gould & Lincoln.

This old acquaintance is always an agreeable reminder of its predecessors of former years, as well as of numerous discoveries, facts and principles in various departments with which we are, as fellow laborers in the great field, more or less familiar, but which it is always pleasant to find marshaled in an orderly and compact manner, under their appropriate heads. Every such review of the year must of necessity be imperfect and unequal as an exposition of all that has been done, but even a cursory glance at Dr. Kneeland's Annual will show any fair-minded reader the vast variety of topics which now engage the attention of scientists, and the pains-taking care with which the editor has endeavored to present the most important results. The notes by the editor, forming an introduction to the volume, give an interesting summary of the progress of science for 1868.—*American Journal of Science and Art.*

MODERN SCREW PROPULSION. By N. P. BURGH, engineer. London: E. and F. N. Spon, 48 Charing Cross. For sale by D. Van Nostrand, 23 Murray street, New York.

Mr. Burgh's treatise on screw propulsion, which was to have been completed in fifteen parts, has been extended to sixteen. This extension has been decided upon in order that the work may embody some very recent important matter on screw propellers, which has been exclusively given to the author by our leading marine engineers. The author has thus exercised a wise discretion in thus extending his work, and to which none of his readers will object. Parts XIII, XIV and XV of this treatise are now before us; they are chapters on a new principle of the screw propeller, by Mr. Arthur Rigg, who has made some very interesting experiments with the screw, the results of which he here embodies. Mr. W. Langdon supplies a chapter on thrust blocks, and Mr. Burgh follows with another on the same subject. In Chapter XX, Mr. Burgh reviews comparatively the whole family of modern screw propellers as constructed by our principal marine engineers. In the succeeding chapter, Mr. Burgh gathers into a focus the opinions and ideas of all the engineers who have contributed to his treatise. In this chapter, the last page of Part XV finds us. The illustrations of these three numbers consist of lifting frames for the screw propeller, the feathering screw of the "Aurora," and the details of the methods of screw propulsion adopted in various other vessels.—*Mechanic's Magazine.*

THE PAINTER, GILDER AND VARNISHER'S COMPANION. Thirteenth edition, revised, with an Appendix. Philadelphia: Henry Carey Baird; New York: S. R. Wells, 389 Broadway.

This book contains rules and regulations in everything relating to the arts of painting, gilding, varnishing, glass-staining, graining, marbling, sign-writing, gilding on glass, and coach painting and varnishing. It also gives tests for the detection of adulterations in oils and colors, and a statement of the diseases to which painters are peculiarly liable, with remedies. It is several years since the first edition of the book was published, and as new editions have been gotten up, additions have been made to bring the work up to the time. The appendix added to the present edition comprises descriptions of a great variety of additional pigments, their qualities and uses, with additional information on dryers, and also contains an explanation of Chevreul's principles of harmony and contrast of colors.—*American Artizan.*

TREATISE ON THE POWER OF WATER. By JOSEPH GLYNN, F. R. S. D. Van Nostrand: New York, 1869.

(Second Notice.) We have had occasion, since receiving this book, to study the literature of water power, professionally and commercially. This fact, together with the corresponding fact that our difficulties have been solved by reference to this book, prompts us to acknowledge its merits in a more decisive form.

There are rules, in the professional pocket books, for measuring the *flow of water*, but it has been reserved for people who sell water, or pay for it, to observe a notable variation in the results of *position* and *shape* of orifices through which water is discharged. If all the information extant is not embodied in the work under consideration, there is enough to solve all ordinary cases.

In addition to the usual historical notice and to the wonted tribute to the power and functions of water, this book contains much interesting information upon the sources of water supply and upon water wheels. It is quite well illustrated and the subject appears to have been very carefully and exhaustively investigated by the author.

THE AMERICAN EXCHANGE AND REVIEW.—A miscellany of useful knowledge and general literature. Especially devoted to Finance, Mining and Metallurgy, Insurance, Railways and Transportation, Manufactures, Patents, Trade, Commerce, Art, Joint Stock Corporation Interests, Physics, Social and Economic Science. Fowler & Moon, 521 Chestnut street, Philadelphia.

This is a monthly of considerable value to students in the subjects mentioned above, and of no little interest to the general reader. It is a sort of connecting link between our literary and scientific serials. The department of mining and metallurgy is conducted by Prof. H. S. Osborn of Lafayette college, and is specially complete and interesting.

A SAPPER'S MANUAL, FOR ENGINEER VOLUNTEER CORPS. By Captain FRANKLAND, R. E. Published under War Office authority.

HINTS ON HOUSE DEFENCE AND BLOCKHOUSES. By Captain YOUNG, 18th Royal Irish. Wellington, New Zealand: Lyon.

MISCELLANEOUS.

SILVER PLATING—OLD AND NEW PROCESSES.—The following is compiled from the Birmingham correspondence of "The Engineer." The old-fashioned process was this:

An ingot of copper, ordinarily weighing about nine pounds, and which had an alloy of brass of one-fifth its weight, was first planed and then filed to a perfectly level surface on both sides; the ingot of silver, containing about 3 per cent of alloy, was rolled to the required thickness for the different qualities of metal to be plated. This was cut into suitable lengths, the weight of the piece of silver varying according to the quality, the lowest being about 16 dwts. for the 9 lbs. of copper for one side only, and increasing to 6 oz or 8 oz. The piece of silver was about $\frac{1}{8}$ in. less than the surface of the copper. It was scraped quite clean on the side next to the copper, great care being necessary that every imperfection should be removed; the two bright surfaces were then laid together and "bedded," by placing a heavy piece of iron on the silver, and striking it with a sledge-hammer till every part of the two surfaces touched. A strong piece of sheet copper was then laid on the silver, to keep it from rising during the process, and also to prevent the wires, which were used to bind the two pieces together from cutting the outer parts of the silver plate. A solution of borax was then laid round the edges of the silver to act as a flux. The ingot thus prepared was then heated in a small furnace until a bright line round the edges of the silver indicated that the union was effected. The ingot was then carefully removed from the fire and cooled gradually. When cold, the wires were cut, the copper plate taken away, the edges carefully filed, and the plated ingot was then ready for the roller.

In the year 1840 the plated ware trade underwent a complete revolution. The process just described was superseded by an invention of Messrs. Elkington, now so well known as electro-plating, by which silver is deposited with accuracy and certainty by the aid of galvanism. This process is essentially dependent upon the original discovery of Volta, the alchemist, in 1799, on which various inventions had been subsequently based. Messrs. Elkington were, however, the first to apply the process successfully to the purposes of practical industry, and their enterprise in this direction took the old-fashioned platers by storm. The opposition they encountered was immense.

The process of plating at Messrs. Elkington's factory is thus described: The article having been thoroughly cleansed, it is plunged first of all into a solution of cyanide of mercury to prevent any oxidation, as well as to secure a perfect adhesion in the plating. It is then transferred to the plating vat, which is divided by plates of silver into regular compartments, the articles being suspended on brass rods with copper wire, and so arranged as to expose an equal amount of surface in each compartment to receive the deposit of silver. The operation of plating is so nicely regulated that the rate at which the silver is being deposited is correctly known, and the large amount of 24 oz. per hour is deposited, perfectly smooth and extremely hard. This, with the thickness of silver, accounts for the great durability of the articles manufactured by Messrs. Elkington. There are several large vats in use, so that some idea may be formed of the large amount of silver deposited in one day. When the article has been in the vat a sufficient length of time it is taken out, rinsed in cold water, and dried. After that it is carefully weighed, and the exact amount of silver on the article is at once seen and registered. In addition to the ordinary batteries used in plating, a very large magneto-electric machine is in constant work.

Asbestos Paper and Cloth.—The Florence correspondent of the New York "Times" (Mar. 27) gives a long account of this new manufacture. Crude asbestos resembles bleached hemp, with long, shining fibres, which may be twisted into threads and woven into cloth, or converted into pulp and made into paper. Asbestos is plentiful in various parts of Italy, and the new processes of treatment have been introduced there. The ancients, however, used asbestos cloth for embalming, and specimens of it are found at Pompeii. The great value of paper made from this substance is its indestructibleness, either by fire or by decay.

Heat of the Stars.—Mr. Huggins has been making experiments with the view of ascertaining the heat of the stars. He employed a thermopile, the face of which was placed in the focus of a telescope. The pile was connected with a galvanometer. The following results were obtained: The mean of a number of observations of Sirius, which did not differ greatly from each other, gives a deflection of the needle of 2°. The observations of Pollux $1\frac{1}{2}$°. No effect was produced on the needle by Castor. In one observation Arcturus deflected the needle 3° in 15 minutes. Regulus gave a deflection of 3°. The observations of the full moon were not accordant. On one night a sensible effect was shown by the needle, but at another time the indications of heat were excessively small, and not sufficiently uniform to be trustworthy. It should be observed that several times anomalous indications were observed, which were not traced to the disturbing cause. The results are not strictly comparable, as it is not certain that the sensitiveness of the galvanometer was exactly the same in all the observations; still it was probably not greatly different.

Magnesite or sepiolite, better known as "meerschaum," is found in masses in stratified alluvial deposits among serpentine. It is a product of the decomposition of carbonate of magnesia, its composition is silica 60.8, magnesia 27.1, water 12.1 in 100 parts. Meerschaum is found in Asia Minor in the plains of Eskii-Sher or Eski-Schehir, in Greece, at Egribos in the island of Negropont, in the isle of Samos, at Kiltschik in Natolia, in the Crimea, at Hrubschitz in Moravia, in Morocco, at Vallecas in Spain (where it is used as a building stone), at Baldissero in Piedmont, in Cornwall, in France (in the departments of the Gard, of Seine et Marne, and of the Seine); but the most remarkable quarries worked at present are situated at Brussa, at the foot of Mount Olympus. When first dug up it is damp, soft and greasy. The Tartars use it as soap to wash linen, and the Arabs of Algeria in the manner in the Moorish baths. In masses it floats on water. The color is grayish-white, white, or with a faint yellowish or reddish tinge.

Coal Ashes as a Fertilizer.—A series of experiments conducted at the Museum of Natural History, Paris, during the past year, by Professor Naudin, on the value of coal ashes as a fertilizer, has resulted in the conclusion that they are neither a manure nor even earth of the most infertile quality. An opinion to this effect has prevailed in this country pretty generally, but it is certain that upon heavy clays, they act as a disintegrator if nothing else. This effect is not, we are convinced, merely mechanical, as a very small amount of coal ashes is sufficient to destroy the adhesiveness of a large amount of clay. At least this was the case in a recent experiment of our own, tried in accordance with the advice of one of the most accomplished florists in New York State. By the application of sifted coal ashes with a very small proportion of well rotted horse manure, we were able to make a thrifty flower garden the first season, upon one of the stiffest soils it has ever been our lot to own.—*Scientific American.*

Mr. Andrew Shanks, inventor of the double slotting drill, and designer, and maker of much heavy and ingenious machinery, well known in England, died recently at Hastings. "Engineering" says, and we can certainly indorse the following: "His universal readiness to assist in carrying out improvements, or afford information on engineering subjects, are too well known to all who ever had occasion to apply to him, and his death, with such a vast amount of unrecorded practical information, must be regarded as a serious loss."

Boiler Explosions.—During the past seven months there have been in the United States sixty-one boiler explosions, the great majority of them involving loss of life.

VAN NOSTRAND'S
ECLECTIC
ENGINEERING MAGAZINE.

No. VIII.—AUGUST, 1869.—Vol. I.

REFORMED SCHOOLS.

Now that college students can rival the ignoble crowd with bat and oars, university culture may be safely advanced another stage, looking to the day when the collegian shall compete with the outsider in other practical branches of knowledge. We deprecate the modern, almighty dollar theory of an exclusively "business" education; we would not *substitute* the most polished scholarship in discount and bookkeeping for the grand old university literature, classical and polite.

The old idea that classical knowledge is an aim and end of education, was, perhaps, more nearly correct than the later idea that classical culture is the only suitable and proper means of working and developing the mind. In this utilitarian age of speculation and greed, of sensational literature, sharp practice and vulgar show, the greatest amount of old fashioned scholarly culture that we can force upon our young men and women will hardly neutralize the leveling tendencies of the times.

But while our schools should not ignore polite culture, they certainly should not neglect practical education. Under the theory that the mind is a machine to be developed, or a power to be disciplined, rather than a storehouse to be filled, are we not overlooking the advantages of positive, technical knowledge? Our new school professors indeed proceed upon the *theory* that the mind can be as well disciplined by practical as by classical studies. But are modern studies practical? Are the greater number of modern English text books really more available to the graduate who has a living and a name to win, than the old Latin ones? There must be one-idea scholars in every branch of knowledge, but are the sublimated mathematics of our "practical" schools either a better universal digester or a better universal resource than Greek roots? If not, then the old fashioned studies have equal advantages in the matter of culture, and the additional dignity of age and scholarly association.

We believe that a comparison of the knowledge wanted in the practical world, with the knowledge furnished in the practical schools, will convince the candid inquirer, 1st. that the course of study is not always well selected; and 2d—and of this we wish particularly to speak—that the books, lectures, references and prescriptions in the departments of learning that purport to be practical and of immediate and every day value, are incomplete and inadequate.

Immediately upon his graduation, in whatever direction his tastes, ambition or necessities may lead him, the young man encounters the *business formulæ* of commerce and production, of which he is ignorant. He may be versed in the elements of political economy, mathematics and chemistry, but he has still to master the rules and forms of practice. He may know the principles of communication with the world, but he has yet to learn the dialects and idioms of business. Mere muscular Training is not more essential to success in athletic sports than mere mental Culture to the triumphs of mind; but Skill plucks the laurels from their brows on the world's playground as well as in the world's workshop. The Latin salutatorian and the Greek versifier of the ancient university, are not much greener than the graduates of "practical" schools when they come to grapple with the first year's work in a business office. This state of things is unnecessary and wrong in every regard. Study is not less a mental tonic because it fits a man to keep books, to write business papers and to buy or make good machinery. And the notorious greenness of graduates in practical affairs, deters many young men from commencing with a theoretical education. It is a grave question in many minds whether skill and training in the arts of life should not precede and lead up to a knowledge of the sciences.

The argument against the dead languages as a means of mental training, when the world is full of live subjects equally difficult to master, is just as valid against practical subjects when taught in an unpractical manner. A man may study mathematics all his life and not be able to earn his bread in a merchant's office or an engineer's drawing room. He may even master all the text books in mechanics and not be able to construct an economical steam engine. We are deceived by the names and cheated of the substance of practical learning. Our universities may well copy the course of training in our *commercial* colleges and our foremost *technical* schools, and so adorn a scholarship that will pay, with the graces of polite and classical culture. At least let us not abandon the studies that not only disciple the mind but liberalize the sentiments and refine the social and intellectual relations of life, until we are prepared to substitute studies that really teach men how to live and thrive—studies that directly and immediately advance the battle of mind against matter—studies that are practical in substance as well as in name.

BLACK LEAD, which has only been used as a lubricator for wooden machinery, and for wood piston packing, is now applied by M. Deloris, in France, to every kind of machine, from the heaviest vehicles to the most delicate watch-work, so dispensing with the use of oils and grease of all kinds. If plumbago can be successfully applied to railway carriages, a great saving to the companies will be effected. It is said to be used with many vehicles in Paris, and in machinery at several factories, and seems to give satisfaction.

PAPERS ON CONSTRUCTION.

No. IV.

IRON ROOFS.

By Lieut. C. E. DUTTON.

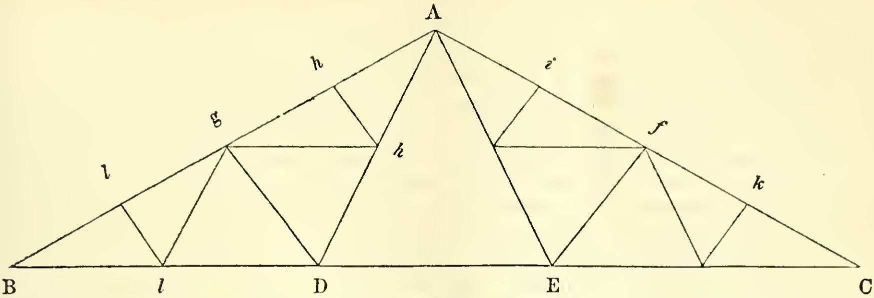
(Continued from page 583.)

A roof owes its stability to a series of similar frames called trusses. The most common form of roof-truss is an isosceles triangle, of which the two equal sides supporting the roof covering are called principal rafters. The rafters are subject to compressive and transverse stress, and are constructed accordingly. The third side is subject only to tensile stress, and is called the tie-rod, or tie-beam, and, in the case of an iron roof, consists of one or more rods of round iron. The stresses which this truss is required to withstand are, 1st, those arising from the weight of the entire roof structure, and 2d, those caused by the weather, viz: wind and snow. For the resistance to these forces the rafter may be treated as an inclined beam supported at each end, and, if desirable, at intermediate points, the lower end abutting against the extremity of the tie-rod, and the upper end against the upper end of the opposing rafter.

The rafters are made either of common rolled T iron, or of two pieces of L, or angle-iron, riveted in such a manner that they form a T. The flange is placed upwards for several reasons, that being the position of gratest strength in a beam of that particular cross-section, besides being most convenient for the attachment of purlins, braces and struts. The tie-rod has a jaw at each end, which receives the web of the rafter to which it is pinned.

In roofs of great span, in order to give the rafter the requisite rigidity, secondary trussing must be resorted to. But in such a case the general principle of the truss is in no respect changed, the variations being merely those of detail and supplementary. The two rafters and the tie-rod still remain, but with the addition of new parts for carrying out the same general design. To secure proper stiffness the rafter is supported in the middle by a strut, which thrusts against a point held in stable equilibrium by two or more forces, whose resultant is equal and opposite to the thrust. Fig. I is a compound truss of the commonest form. The junction of each part will readily suggest itself upon a simple inspection of the diagram.

Fig. I.



Assuming that in a roof of given length, measured along the ridge, the rafters are placed at equal distances apart, the weight of superstructure to be sustained by each will be equal to the weight of material between any two consecutive rafters. To this must be added the weight of the rafter itself, with its appurtenances, and a suitable calculation should be made of the maximum amount of snow which may accumulate upon it, and of the force of the wind. Of these the weight of the rafter is an unknown quantity. The others may be readily determined after the pitch, or slope of the roof, is decided upon.

To determine the stress upon the various parts.—Let W represent the weight of a section of the roof between two consecutive principles. Each rafter will then support one half this weight. The mutual support afforded at the apex is transmitted to the walls at B and C, so that each wall sustains one-half the load. Although the load is uniformly distributed, we may consider it as concentrated at A with a vertical resultant $= \frac{1}{2}$ W. This resultant may be resolved into two components acting along the rafters A B and A C with forces $= \frac{1}{2} (\frac{1}{2} \text{W cosec } \phi)$, in which expression ϕ represents the angle of the slope of the roof. Since cosec. $= \frac{\text{R}}{\text{sin.}}$ we may put the expression for the thrust into the following form: $t = \frac{1}{4} \frac{\text{W}}{\text{sin. } \phi}$ This thrust is opposed by two forces, one of which is the upward resistance of the wall; the other, the pull of the tension rod. Hence we may divide it into two components, r' and r.

$$r' = t \text{ sin. } \phi = \frac{1}{4} \frac{\text{W}}{\text{sin. } \phi} \text{ sin. } \phi = \frac{1}{4} \text{W}$$

$$r = t \cos \phi = \frac{1}{4} \frac{\text{W}}{\text{sin. } \phi} \cos. \phi = \frac{1}{4} \frac{\text{W}}{\text{tan. } \phi}.$$

In the equation $r' = \frac{1}{4}$ W, only half the weight is actually considered, viz: that portion which is directly supported at the apex and transmitted by the thrust of the rafters to the top of the wall. But each wall supports directly $\frac{1}{4}$ W, which, added to the quantity obtained. makes $\frac{1}{2}$ W, which represents the entire supporting force of each wall.

The stresses sustained by the minor component parts of a compound truss must be determined separately, and for this purpose we must ascertain the distribution of the load over the points B, l, g, h, A. Since $\frac{1}{2}$ W is equally distributed over each rafter we may consider B l, l g, g h, h A, as so many separate, uniformly loaded beams, resting upon their respective points of support, with stresses equal to $\frac{1}{16}$ W at each end, so that the direct stresses as thus considered are, at A and B $\frac{1}{16}$ W each, and at l, g, h, $\frac{1}{8}$ W each. But the stresses at l and h are transmitted through the struts $l\ l'$, $h\ h'$ to their respective suspending rods (braces), and by the braces to the points B, g, A. A simple inspection of the diagram will show that the resultant of the pulls along $g\ h'$ and $g\ l'$ will be equal to $\frac{1}{8}$ W along g D. This stress, added to the direct stress at g, gives $\frac{1}{4}$ W for the total stress at that point. The tension along $g\ h'$ and A h', $g\ l'$ and B l' is, in each case, $\frac{1}{16} \frac{\text{W}}{\text{sin. } \phi} \cos. \phi$. By the same reasoning it will appear that the tension along B D and D A must be $\frac{1}{8} \frac{\text{W}}{\text{sin. } \phi} \cos. \phi$. It has already been shown that the tension along B C, due to the primary thrust of the abutting rafters, is $\frac{1}{4} \frac{\text{W}}{\text{sin. } \phi} \cos. \phi$. Hence the pull along B l is $\frac{\text{W}}{\text{tan. } \phi} (\frac{1}{4} + \frac{1}{8} + \frac{1}{16})$; the pull along l 'D is $\frac{\text{W}}{\text{tan. } \phi} (\frac{1}{4} + \frac{1}{8})$, and the pull along D E is $\frac{\text{W}}{\text{tan. } \phi} (\frac{1}{4})$.

It is apparent that the braces produce a compressive stress in the rafter in addition to the direct thrust caused by the weight of the opposing rafter. A g D and B g D may be considered as triangles of forces in equilibrium. By taking one-half the weight imposed upon the strut g D $\frac{1}{8}$ W, we have at once the means of determining the forces acting upon the other sides of each triangle. It has already been shown that the pulls along A D and B D are $\frac{1}{8}\,\frac{W}{\tan.\ \phi}$, and the compression of the rafter due to these two pulls must be $\frac{1}{8}\,\frac{W}{\tan.\ \phi}\cos.\ \phi = \frac{1}{8}\,\frac{W}{\sin.\ \phi}$ In the same way it may be shown that the compression produced by the braces A h' and $g\ h'$, $g\ l'$ and B l' is $\frac{1}{16}\,\frac{W}{\sin.\ \phi}$. Hence the total compression is

$$P = \frac{W}{\sin.\ \phi}\left(\tfrac{1}{4} + \tfrac{1}{8} + \tfrac{1}{16}\right).$$

The pressures upon the struts g D and $l\ l'$ are respectively $\frac{1}{8}$ W and $\frac{1}{16}$ W.

Many trusses are constructed with the tie-rod raised above the horizontal, as in Fig. II. the tension on the rod D E will always vary inversely, as its perpendicular distance from A, *i. e.* tension on B C : tension on D E :: A b': A b. The tension on the braces may be formed as before.

An excellent method of trussing, and one very extensively employed in England for moderate spans, is shown in Fig. III. It is known as the king and queen post truss, $a\ a'$, $b\ b'$, $c\ c'$, &c., are struts, and $a\ b'$, $b\ c'$, $c\ d'$, &c., are suspension rods, and their arrangement is such that B d' c, B c' b, B b' a, &c., may be considered as braces holding each its own strut. Assuming, as in the first example, that B d, $d\ c$, $c\ b$, &c., are separate beams, each supported at its extremities, then (assuming also that there are four secondary trusses), the distribution of the load is as follows: $\frac{1}{5}$ the weight of the rafter, or $\frac{1}{10}$ W, rests directly on each of the points a, b, c, d, and $\frac{1}{20}$ W on A σ B. By means of the braces and struts one-half the weight at d is transmitted to c, $\frac{2}{3}$ the weight at c to b, $\frac{3}{4}$ the weight at b to a, and $\frac{4}{5}$ the weight at a to A. If we resolve the thrust along any one one of the struts, for

Fig. II.

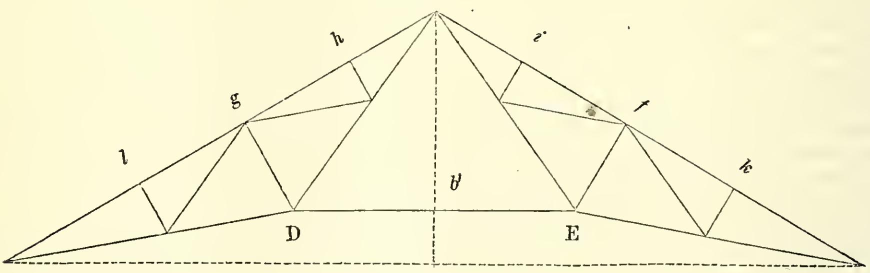
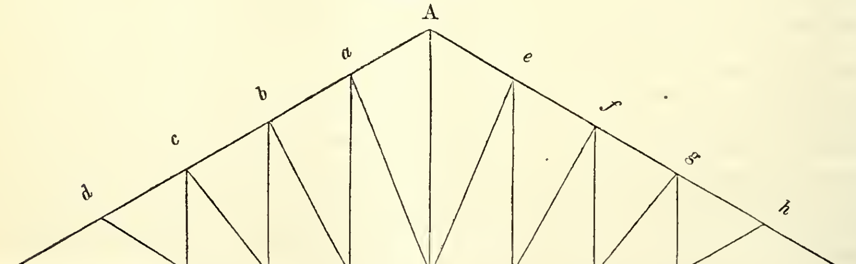


Fig. III.



We have ascertained that the tension on a rod from B to C would be $t = \frac{1}{4}\,\frac{W}{\tan.\ \phi}$. An inspection of the diagram will show that instance $b\ b'$, into the two components which withstand it, viz: $b'\ c'$ and $c'\ b$, the former will represent the additional pull on the tie rod, and the latter the pull on the queen-post $a\,b'$ caused by the stress at b'. Treating the stresses at the other points in the same manner, we shall find that they all give rise to equal additional pulls on the tie-rod. But the pull on the tie-rod produced by the strut $d\,d'$ is $\frac{1}{20}\cdot\frac{W}{\tan.\phi}$. Hence the tensions on the tie-rod are

$$\text{Between } a'\,b' = \frac{W}{\tan.\phi}\left(\tfrac{1}{4}+\tfrac{1}{20}\right).$$

$$\text{“} \quad b'\,c' = \frac{W}{\tan.\phi}\left(\tfrac{1}{4}+\tfrac{2}{20}\right).$$

$$\text{“} \quad c'\,d' = \frac{W}{\tan.\phi}\left(\tfrac{1}{4}+\tfrac{3}{20}\right).$$

$$\text{“} \quad d'\,B = \frac{W}{\tan.\phi}\left(\tfrac{1}{4}+\tfrac{4}{20}\right).$$

and the tensions on the queen-posts are,

$$\text{on } c\,d' = \tfrac{1}{10}\ W$$
$$b\,c' = \tfrac{3}{20}\ W$$
$$a\,b' = \tfrac{1}{5}\ W$$
$$A\,a' = \tfrac{1}{2}\ W.$$

The king post A a', it will be observed, receives the stresses from two struts—$a\,a'$, $e\,a'$.

The few illustrations we have given contain the main principles involved in the operation of. forces upon the frame work of triangular roofs of moderate size. The variations of detail may be almost infinite, and they are sometimes very complicated, but are easily reducible to simple thrusts and pulls, and to parallelograms of forces.

In iron roofs the trusses described are made to serve the purposes of both principal and common rafters. The distances between them may vary, according to circumstances, from 3 ft. to 30 ft. In the latter case, and in all cases where a considerable interval between rafters is desirable, the purlins must be trussed. The foot of the rafter may be received into a cast-iron saddle bolted to the wall plate, and the main tie-rod may be jawed and riveted to the web of the rafter, or may pierce the casting and be fastened by a key or pin, or thread and nut. These matters of minor detail are always highly variable and are determined simply by considerations of convenience. In this climate and latitude, provision should be made for varying the length of the main tie to adapt it to the wide ranges of temperature, and this is best accomplished by a swivel-nut in the center.

The purlins are bars of iron, crossing the rafters at right angles, and to them the roof covering is directly attached. The most suitable form is ordinarily a double flanged bar or rail, of such a length that its ends shall rest upon rafters.

The roof covering may be wood or iron. In the former case it is shingled or tiled, and in the latter corrugated iron is by far the best material. Corrugated iron may be obtained in sheets of any length not exceeding 8 ft., and the length of the sheets should be a multiple of the length of the rafter, added to the proper allowance for overlaps. Thus, a rafter 27 ft. long will require four lengths of 7 ft., 4 in. being allowed for each of the three overlaps. But the lateral joints would present a difficulty if the plates or sheets were of uniform length, since, in that case, the intersection of a lateral and terminal joint would involve the superposition of the corners of four sheets, which must be avoided by breaking joints in alternate courses. Hence a certain proportion of the sheets (easily determined by the circumstances of the case) should be ordered of extra length and an equal number of inferior length. In the case supposed of a 27 ft. rafter, one 8 ft. and one 6 ft. plate should be ordered for every six plates of 7 ft. The junction at the ridge is best effected by a cast-iron covering, sloping in both directions for a few inches, and with its edges corrugated to fit the surfaces of the plates, and overlapping them a few inches. This casting should be made of the best iron in the most accurate manner and of the least thickness consistent with sound casting. Openings for ventilators may be left in them if desirable. The plates should be prepared, before laying them, with a good coating of mineral paint, in which oxide of iron is a principal constituent.

We introduce a portion of an article by Mr. J. J. Birckel, published in the London "Artizan," upon the accidental stresses to which a roof may be subjected. "Among the accidental sources of pressure, wind and snow form the most important items, because both may occur simultaneously. According to General Morin's observations, snow may accumulate to the depth of 20 in., and as its weight is $\frac{1}{10}$th that of water, the pressure due to this element would be about 11 lbs. per square ft. The same philosopher, however, thinks that one-half this amount will make ample provision. We will keep on the safe side, and suppose it to be 6 lbs. per square ft. Respecting the wind, we subjoin a short table of the pressures produced at various speeds upon a plane of resistance supposed to be at right angles with the direction of the wind:

Speed in ft. per second.	Pressure per sq. ft.	Speed in ft. per second.	Pressure per sq. ft.
ft. in.		ft. in.	
10 0	0.2	46 0	4.7
13 9	0.6	65 7	9.6
26 3	1.5	131 0	38.4
35 7	2.8		

General Morin, from whose work the above data are quoted, thinks that a direct pressure of 3 lbs. per square ft. is quite sufficient to reckon upon; but English engineers differ from him on this point, and make allowance for a pressure of 7 or 8 lbs. per ft." [In this country, where tornadoes are not unfrequent, this allowance should be still greater, though the chief danger to be apprehended from such disasters is the access of the wind to the underside of the roof, through windows and elsewhere.] "In the following tables we give the items of permanent pressure due to the covering, and to the structure of the roof itself, which, added to the items previously defined, will make up the whole weight, which must form the basis of calculation of the strength of the roof:

Nature of Covering.	Weight in lbs. per sq. ft.
Common tiles	13
Hollow tiles	16 to 18
Slates	8
Rolled copper	3
Zinc	2
Galvanized sheet iron	2
Corrugated sheet iron	$2\frac{1}{2}$
Asphalte	$5\frac{1}{4}$

Table of Weights of Principals and Purlins.

Distance between principals	Span.	Weight of principal.	Weight of purlins for one bay.	Weight per sq. ft. of roof'g.
ft. in.	ft. in.	lbs.	lbs.	lbs.
6 6	26 0	137	225	2.03
6 6	40 0	337	290	2.20
6 6	65 9	888	418	2.87
6 6	82 0	1,668	482	3.80
9 10	26 0	194	508	2.59
9 10	40 0	502	653	2.76
9 10	65 9	1,387	943	3.39
9 10	82 0	2,625	1,088	4.34
13 1	26 0	245	959	3.33
13 1	40 0	580	1,233	3.26
13 1	65 9	1,705	1,781	3.81
13 1	82 0	2,755	2,055	4.22

Mean weight per sq. ft. 3.22 lbs.

Observations.—These data are quoted from Gen. Morin's work; principals supposed to be trussed as per diagram No. 2; their weight has been increased by the amount of one-fourth for deficiency in rafters; angle of roof about 25°.

If, now, we sum up the pressures arising from the various sources enumerated, we shall find that the loads per square foot, for different kinds of covering, are as follows:

Nature of Covering.	Weight in lbs. per sq. ft.
Common tiles	33
Hollow tiles	29
Slates	28
Rolled copper	23
Zinc	22
Galvanized sheet iron	22
Corrugated sheet iron	$22\frac{1}{2}$
Asphalte	$27\frac{1}{4}$

The load of 40 lbs. per sq. ft., which is generally taken by English engineers as a basis in the calculation of roofs, is by no means exaggerated, though it may be quite sufficient.

Aero-Steam Engines.—Some interesting trials of Warsop's air and steam engine have been for some time in progress at Nottingham; and the report upon the results has been made by a well-known and, in such matters, very painstaking London engineer. The engine, being started by steam in the ordinary manner, a single-acting air pump, worked from the crank-shaft, compresses air to a little more than the boiler pressure, the air thus passing through a long circuit of straight and coiled pipe, which traverses the exhaust pipe, makes several spiral coils in the chimney, then descends at one side of the firebox, exposed to the full fire, and finally connects with a valve-box, through which the air, more or less heated, enters the boiler at the bottom of the water space. So far as the experiments—carefully made upon an imperfect engine, worked alternately with steam alone and with steam and air—can be taken as establishing a principle, they indicate a considerable economy—an economy, however, beyond anything which, as yet, is inferable from theory. Further experiments upon a new and greately improved engine on Warsop's system are arranged to take place very shortly, when the results will be laid before our readers.—*Engineering.*

REMARKABLE ENDURANCE OF BESSEMER STEEL AXLES.

The following table gives in detail, the tests of several steel axles, taken at random from a number of axles made by the Pennsylvania Steel Company, out of their regular product of Bessemer steel.

The first test shows, probably, the most remarkable endurance on record, viz: bending backward and forward under a ton drop falling forty-six times from a height of $16\frac{1}{2}$ feet, and twelve times from a height of 18 feet, the axle being reversed after each blow, and the total deflection back and forth being 163 inches.

TESTS OF BESSEMER STEEL AXLES *made at the Pennsylvania Steel Works, Baldwin, near Harrisburgh, Pa., May,* 1869.

[Weight of drop 2,000 lbs. V shaped wrought iron tup. Bearings 3 feet apart on cast iron supports.]

No. of blow.	He'ght of fall.	Deflection.—Inches. Before blow.	After blow.	Effect of blow.	Total.
	ft. in.				
1	16 6	— .00	⌣ 3.44	3.44	3.44
2	do	⌒ 3.44	— .00	3.44	6.88
3	do	— .00	⌣ 3.06	3.06	9.94
4	do	⌒ 3.06	— .00	3.06	13.
5	do	— .00	⌣ 2.88	2.88	15.88
6	do	⌒ 2.88	— .00	2.88	18.75
7	do	— .00	⌣ 3.	3.	21.75
8	do	⌒ 3.	— .00	3.	24.75
9	do	— .00	⌣ 3.	3.	27.75
10	do	⌒ 3.	— .00	3.	30.75
11	do	— .00	⌣ 3.	3.	33.75
12	do	⌒ 3.	— .00	3.	36.75
13	do	— .00	⌣ 2.75	2.75	39.5
14	do	⌒ 2.75	— .00	2.75	42.25
15	do	— .00	⌣ 3.	3.	45.25
16	do	⌒ 3.	— .00	3.	48.25
17	do	— .00	⌣ 3.19	3.19	51.44
18	do	⌒ 3.19	— .00	3.19	54.62
19	do	— .00	⌣ 3.12	3.12	57.75
20	do	⌒ 3.12	— .00	3.12	60.88
21	do	— .00	⌣ 3.12	3.12	64.
22	do	⌒ 3.12	— .00	3.12	67.12
23	do	— .00	⌣ 3.19	3.19	*70.31
24	do	⌒ 3.19	⌣ .25	3.44	73.75
25	do	⌒ .25	⌣ 3.12	3.38	†77.12
26	do	⌒ 3.12	⌣ 1.	4.12	81.25
27	do	⌒ 1.	⌣ 1.	2.	83.25
28	do	⌒ 1.	⌣ 1.5	2.5	85.75
29	do	⌒ 1.5	⌣ 1.	2.5	88.25
30	do	⌒ 1.	⌣ 1.38	2.38	90.62
31	do	⌒ 1.38	⌣ 1.25	2.62	93.25
32	do	⌒ 1.25	⌣ 1.5	2.75	96.
33	do	⌒ 1.5	⌣ 1.12	2.62	98.62
34	do	⌒ 1.12	⌣ 1.62	2.75	101.38
35	do	⌒ 1.62	⌣ 1.12	2.75	104.12
36	do	⌒ 1.12	⌣ 1.5	2.62	106.75
37	16 6	⌒ 1.5	⌣ .88	2.38	109.12
38	do	⌒ .88	⌣ 1.62	2.5	111.62
39	do	⌒ 1.62	⌣ .88	2.5	114.12
40	do	⌒ .88	⌣ 1.75	2.62	116.75
41	do	⌒ 1.75	⌣ .88	2.62	119.38
42	do	⌒ .88	⌣ 1.75	2 62	122.
43	do	⌒ 1.75	⌣ .88	2.62	124.88
44	do	⌒ .88	⌣ 1.62	2.5	127.12
45	do	⌒ 1.62	⌣ .75	2.38	129.5
46	18	⌒ .75	⌣ 1.62	2.38	131.88
47	do	⌒ 1.62	⌣ 1.	2.62	134.5
48	do	⌒ 1.	⌣ 1.75	2.75	137.25
49	do	⌒ 1.75	⌣ 1.25	3.	140.25
50	do	⌒ 1.25	⌣ 1.75	3.	143.25
51	do	⌒ 1.75	⌣ 1.5	3.25	146.5
52	do	⌒ 1.5	⌣ 1.75	3.25	149 75
53	do	⌒ 1.75	⌣ .88	2.62	152.38
54	do	⌒ .88	⌣ 1.75	2.62	155.
55	do	⌒ 1.75	⌣ .88	2.62	157.62
56	do	⌒ 88	⌣ 1.75	2.62	160.25
57	do	⌒ 1.75	⌣ 1.	2.75	163.
58	do	⌒ 1.	———	broke.	

* Turned $\frac{1}{4}$ over between 23d and 24th blows, as axle was bent sidewise by 23d blow.

† Turned $\frac{1}{4}$ over for same reason, between 25th and 26th blows.

No. of blow.	He'ght of fall.	Before blow.	After blow.	Effect of blow.	Total.
1	16 6	— .00	⌣ 2.88	2.88	2.88
2	do	⌒ 2.88	— .00	2.88	5.75
3	do	— .00	⌣ 2.5	2.5	8.25
4	do	⌒ 2.5	— .00	2.5	10.75
5	no	— .00	⌣ 2.5	2.5	13.25
6	do	⌒ 2.5	— .00	2.5	15.75
7	do	— .00	⌣ 2.5	2.5	18.25
8	do	⌒ 2.5	— .00	2.5	20.75
9	do	— .00	⌣ 2.5	2.5	23.25
10	do	⌒ 2.5	— .00	2.5	25.75
11	do	— .00	⌣ 2.62	2.62	28.38
12	do	⌒ 2.62	— .00	2.62	31.
13	do	— .00	⌣ 2.75	2.75	33.75
14	do	⌒ 2.75	— .00	2 75	36.5
15	do	— .00	⌣ 2.62	2.62	39.12
16	do	⌒ 2.62	— .00	2 62	41.75
17	do	— .00	⌣ 2.75	2.75	44.5
18	do	⌒ 2.75	— .00	2.75	47.25
19	do	— .00	⌣ 2.75	2.75	50.
20	do	⌒ 2.75	— .00	2.75	52.75
21	do	— .00	⌣ 2.75	2.75	55.5
22	do	⌒ 2.75	— .00	2.75	58.25
23	do	— .00	⌣ 1.75	1.75	60.
24	do	⌒ 1.75	⌣ 1.25	3.	63.
25	do	⌒ 1.25	⌣ 1.5	2.75	*65.75
26	do	⌒ 1.5	⌣ 1.38	2.88	†68.62
27	do	⌒ 1.38	⌣ 1.25	2.62	71.25
28	do	⌒ 1.25	⌣ 1.5	2.75	74.
29	do	⌒ 1.5	⌣ 1.38	2.88	76.88
30	d6	⌒ 1.38	⌣ 1.	2.38	79.25
31	do	⌒ 1.	⌣ 1.5	2.5	81.75
32	do	⌒ 1.5	⌣ 1.5	3.	‡84.75
33	do	⌒ 1.5	⌣ 1.25	2.75	87.5
34	do	⌒ 1.25	⌣ 1.62	2.88	90.38
35	do	⌒ 1.62	⌣ 1.12	2.75	93.12
36	do	⌒ 1.12	⌣ 1.5	2.62	§95.75
37	do	⌒ 1.5	⌣ 1.25	2.75	98.5
38	do	⌒ 1.25	⌣ 1.5	2.75	101.25
39	do	⌒ 1.5	———	broke.	

* A little crack about $\frac{1}{2}$ in. × 1-16 in. opened on *under side,* about $1\frac{1}{4}$ in. from point struck on top side.

† This crack was struck and closed up.

‡ Same crack opened a little wider.

§ Crack keeps opening.

No. of blow.	He'ght of fall.	DEFLECTION.—INCHES. Before blow.	After blow.	Effect of blow.	Total.
	ft. in.				
1	16 6	— .00	⌣ 2.	2.	2.
2	do	⌒ 2.	— .00	2.	4.
3	do	— .00	⌣ 2.	2.	6.
4	do	⌒ 2.	⌣ .38	2.38	8.38
5	do	⌒ .38	⌣ 1.75	2.12	10.5
6	do	⌒ 1.75	⌣ .38	2.12	12.62
7	do	⌒ .38	⌣ 1.88	2.25	14.88
8	do	⌒ 1.88	⌣ .5	2.38	17.25
9	do	⌒ .5	⌣ 1.75	2.25	19.5
10	do	⌒ 1.75	⌣ .5	2.25	21.25
11	do	⌒ .5	⌣ 1.62	2.12	23.88
12	do	⌒ 1.62	⌣ .5	2.12	26.
13	do	⌒ .5	⌣ 1.75	2.25	28.25
14	do	⌒ 1.75	⌣ .38	2.12	30.38
15	do	⌒ .38	⌣ 1.75	2.12	32.5
16	do	⌒ 1.75	⌣ .38	2.12	34.62
17	do	⌒ .38	⌣ 1.62	2.	36.62
18	do	⌒ 1.62	⌣ .38	2.	38.62
19	do	⌒ .38	⌣ 1.75	2.12	40.75
20	do	⌒ 1.75	⌣ .5	2.25	43.
21	do	⌒ .5	⌣ 1.62	2.12	45.12
22	do	⌒ 1.62	⌣ .5	2.12	47.25
23	do	⌒ .5	⌣ 1.75	2.25	49.5
24	do	⌒ 1.75	⌣ .38	2.12	51.62
25	do	⌒ .38	⌣ 1.62	2.	53.62
26	do	⌒ 1.62	⌣ .38	2.	55.62
27	do	⌒ .38	⌣ 1.62	2.	57.62
28	do	⌒ 1.62	⌣ .38	2.	59.62
29	do	⌒ .38	⌣ 1.75	2.12	61.75
30	do	⌒ 1.75	⌣ .38	2.12	63.88
31	do	⌒ .38	⌣ 1.75	2.12	66.
32	do	⌒ 1.75	⌣ .5	2.25	68.25
33	do	⌒ .5	⌣ 1.75	2.25	70.5
34	do	⌒ 1.75	⌣ .38	2.12	72.62
35	do	⌒ .38	⌣ 1.62	2.	74.62
36	do	⌒ 1.62	⌣ .38	2.	76.62
37	do	⌒ .38	⌣ 1.75	2.12	78.75
38	do	⌒ 1.75	⌣ .25	2.	80.75
39	do	⌒ .25	⌣ 1.75	2.	82.75
40	do	⌒ 1.75	⌣ .5	2.25	85.
41	do	⌒ .5	⌣ 1.62	2.12	87.12
42	do	⌒ 1.62	⌣ .38	2.	89.12
43	do	⌒ .38	⌣ 1.62	2.	91.12
44	do	⌒ 1.62	⌣ .5	2.12	93.25
45	do	⌒ .5	⌣ 1.75	2.25	95.5
46	do	⌒ 1.75	———	broke.	
1	do	— .00	⌣ 2.88	2.88	2.88
2	do	⌒ 2.88	— .00	2.88	5.75
3	do	— .00	⌣ 2.5	2.5	8.25
4	do	⌒ 2.5	— .00	2.5	10.75
5	do	— .00	⌣ 2.5	2.5	13.25
6	do	⌒ 2.5	— .00	2.5	15.75
7	do	— .00	⌣ 2.5	2.5	18.25
8	do	⌒ 2.5	— .00	2.5	20.75
9	do	— .00	⌣ 2.5	2.5	23.25
10	do	⌒ 2.5	— .00	2.5	25.75
11	do	— .00	⌣ 2.5	2.5	28.25
12	do	⌒ 2.5	— .00	2.5	30.75
13	do	— .00	⌣ 2.62	2.62	33.38
14	do	⌒ 2.62	— .00	2.62	36.
15	do	— .00	⌣ 2.56	2.56	38.56
16	do	⌒ 2.56	— .00	2.56	41.12
17	do	— .00	⌣ 2.75	2.75	43.88
18	do	⌒ 2.75	— .00	2.75	46.62
19	do	— .00	⌣ 2.75	2.75	49.38
20	do	⌒ 2.75	— .00	2.75	52.12
21	do	— .00	⌣ 2.5	2.5	54.62
22	do	⌒ 2.5	— .00	2.5	57.12
23	do	— .00	⌣ 2.62	2.62	59.75
24	do	⌒ 2.62	— .00	2.62	62.38

No. of blow.	He'ght of fall.	DEFLECTION.—INCHES. Before blow.	After blow.	Effect of blow.	Total.
	ft. in.				
25	16 6	— .00	⌣ 2.75	2.75	65.12
26	do	⌒ 2.75	— .00	2.75	67.88
27	do	— .00	⌣ 2.75	2.75	70.62
28	do	⌒ 2.75	— .00	2.75	73.38
29	do	— .00	⌣ 2.88	2.88	76.25
30	do	⌒ 2.88	— .00	2.88	79.12
31	do	— .00	⌣ 2.88	2.88	82.
32	do	⌒ 2.88	— .00	2.88	84.88
33	do	— .00	⌣ 2.88	2.88	87.75
34	do	⌒ 2.88	— .00	2.88	90.62
35	do	— .00	⌣ 2.88	2.88	93.5
36	do	⌒ 2.88	———	broke.	
1	do	— .00	⌣ 2.88	2.88	2.88
2	do	⌒ 2.88	— .00	2.88	5.75
3	do	— .00	⌣ 2.56	2.56	8.31
4	do	⌒ 2.56	— .00	2.56	10.88
5	do	— .00	⌣ 2.5	2.5	13.38
6	do	⌒ 2.5	— .00	2.5	15.88
7	do	— .00	⌣ 2.38	2.38	18.25
8	do	⌒ 2.38	— .00	2.38	20.62
9	do	— .00	⌣ 2.25	2.25	22.88
10	do	⌒ 2.25	— .00	2.25	25.12
11	do	— .00	⌣ 2.31	2.31	27.44
12	do	⌒ 2.31	— .00	2.31	29.75
13	do	— .00	⌣ 2.5	2.5	32.25
14	do	⌒ 2.5	— .00	2.5	34.75
15	do	— .00	⌣ 2.31	2.31	37.06
16	do	⌒ 2.31	— .00	2.31	39.38
17	do	— .00	⌣ 2.5	2.5	41 88
18	do	⌒ 2.5	— .00	2.5	44.38
19	do	— .00	⌣ 2.38	2.38	46.75
20	do	⌒ 2.38	— .00	2.38	49.12
21	do	— .00	⌣ 2.5	2.5	51.62
22	do	⌒ 2.5	— .00	2.5	54 12
23	do	— .00	⌣ 2.38	2.38	56.5
24	do	⌒ 2.38	— .00	2.38	58.88
25	do	— .00	⌣ 2.38	2.38	61.25
26	do	⌒ 2 38	— .00	2.38	63.62
27	do	— .00	⌣ 2.62	2.62	66.25
28	do	⌒ 2.62	— .00	2.62	68.88
29	do	— .00	⌣ 2.62	2.62	71.5
30	do	⌒ 2.62	— .00	2.62	74 12
31	do	— .00	⌣ 2.75	2.75	76.88
32	do	⌒ 2.75	———	broke.	
		NO CRACKS OR FLAWS.			
1	do	— .00	⌣ 2.88	2.88	2.88
2	do	⌒ 2.88	— .00	2.88	5.75
3	do	— .00	⌣ 2.5	2.5	8.25
4	do	⌒ 2.5	— .00	2.5	10.75
5	do	— .00	⌣ 2.62	2.62	13.38
6	do	⌒ 2.62	— .00	2.62	16.
7	do	— .00	⌣ 2.62	2.62	18.62
8	do	⌒ 2.62	— .00	2.62	*21.25
9	do	— .00	⌣ 2.62	2.62	23.88
10	do	⌒ 2.62	— .00	2.62	26.5
11	do	— .00	⌣ 2.75	2.75	29.25
12	do	⌒ 2.75	— .00	2.75	32.
13	do	— .00	⌣ 2.62	2.62	34.62
14	do	⌒ 2.62	— .00	2.62	37.25
15	do	— .00	⌣ 2.62	2.62	39.88
16	do	⌒ 2.62	— .00	2.62	42.5
17	do	— .00	⌣ 2.5	2.5	45.
18	do	⌒ 2.5	———	broke.†	

* Turned 1-16th over so as to hit squarely; turned back after next blow.

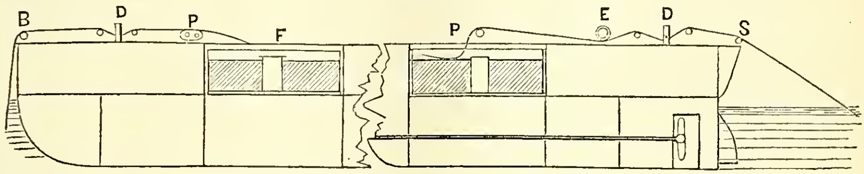
† At point where struck, 2 small longitudinal surface cracks at under side, at time of last blow.

THE FRENCH ATLANTIC CABLE.

From "The Engineer."

In another column will be found a summary of a very interesting lecture by Mr. Fleeming Jenkin, one of the electricians engaged in the new Atlantic cable expedition, containing much information about the method of laying the French cable. We are indebted to Mr. Jenkin for the accompanying diagrams, which show some of the essential points of the appliances to be used to submerge the cable. Fig. 1 is a section of the Great Eastern, showing the tanks containing the cable, and the position of the paying-out and picking-up machinery; B is the bow-wheel over which the cable is hauled in; D the dynamometer; P the picking-up wheel; and F the fore-tank. The main tank is omitted; P aft-tank; E paying-out drum; D the dynamometer, and S the stern wheel, with the cable running out into the ocean.

Fig. 1.



Figs. 2 and 3 represent the most important part of the paying-out machinery, invented by the late Mr. Appold. Fig. 2 shows the principle of Appold's brake. In this cut O is the pivot of the break-wheel, and C the pivot on which the lever C, A, B works. W is the weight on the brake. The brake-wheel is attached to the paying-out drum. When the friction of the brake strap is greater than the weight W, the latter is lifted up, and as C, A, B is shorter than O, A, B, the change of angle relaxes the brake strap, and lets the wheel slip. In this way the strain on the cable never can exceed that of the weight W. Fig. 3 shows Appold's brake drum. In this cut C is the center on which the lever hangs, to which the weight W is attached, and applies pressure to the strap on the break wheel of the paying out drum. To prevent the weight W from vibrating, there is a piston at P, fitting closely into a cylinder containing water. T is a capstan wheel for lifting up the weight W when the paying-out machinery is entirely released from the brake.

Fig. 2.

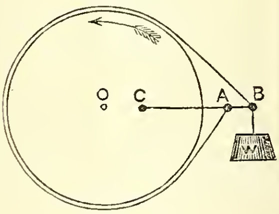


Fig. 4 shows the picking-up catenaries. In the upper part of the cut, M represents the grapnel at the surface of the water, showing the catenary which would be formed by a cable paid out with 14 per cent of slack and lifted in a depth of 2,000 fathoms. In the lower part of the cut, S represents the Great Eastern, and B, M, two auxiliary vessels simultaneously lifting the cable. M is a sharp grapnel intended to cut the cable, and so reduce the strain upon the cable at S.

Fig. 3.

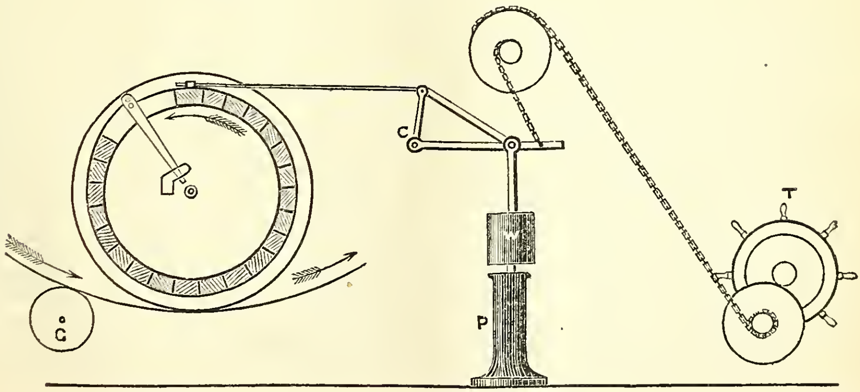


Fig. 4.

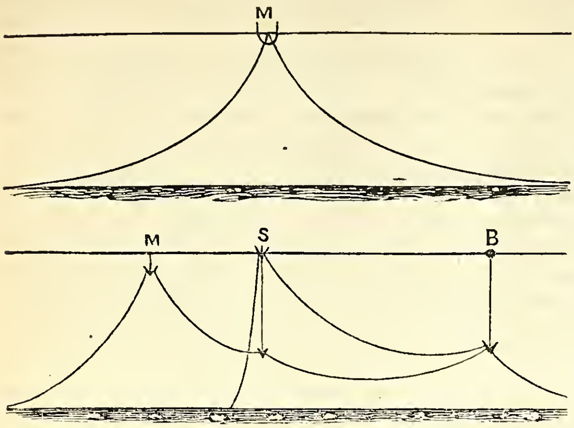
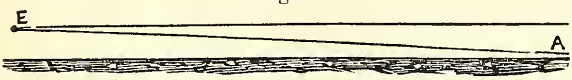


Fig. 5, representing the paying out of the cable, shows the angle at which the cable lies behind the ship in paying out at four knots per hour. E is the Great Eastern, and A the point where the cable reaches the bottom of the ocean, the practical depth of the water being 2,000 fathoms.

The shore ends of the French-Atlantic

Fig. 5.



cable are very heavy, but taper as they reach the deep sea portions. They have the same core as the main cable, and at the end furthest from the shore are each covered with twelve BB galvanized iron wires, .238 in. in diameter, weighing not less than 11,160 lbs. per knot. The heavy shore end next the landing places is first covered with twelve BB galvanized iron wires, nineteen inches in diameter, served with a sufficient quantity of tarred yarn to form a bedding for twelve strands, each formed of three galvanized iron wires .230 inches in diameter, giving a total weight of iron per knot of not less than 38,000 lbs. All the iron wire is of the quality known as "best best," free from inequalities, galvanized, annealed, and capable of being bent round itself and unbent without breaking. There is no weld or joint in any of the iron wires within twelve feet of any other weld. The shore ends are further covered, outside the iron wires, with two coatings of mineral pitch and silica, in the proportions of sixty and forty parts respectively, with sufficient mineral tar to give the requisite consistence, and with two servings of tar hemp yarn, laid alternately, the first coating of yarn being next the wires, then a serving of compound, then the yarn again, and lastly compound. The compound was applied hot and the yarn was laid over immediately afterwards. The yarn is everywhere covered with the compound, so that the outsides of the shore ends are smooth and regular. There are 18 knots of the heaviest shore end, and 127 knots of the lightest shore end; very little of this heavy cable will be laid off the coast of France, but a great deal off St. Pierre. At each end of the deep sea cable there will be a taper a quarter of a mile long, joining it to the shore ends.

The joints in the iron wires are made by scarphing the ends, binding them with fine wires and soldering them, each wire being also served with the best Manilla or New Zealand hemp steeped in tar. The conductor consists of a strand of seven wires of annealed copper, with an electrical resistance per knot at a temperature of 75 deg. Fah. of not more than 3.25 British Association units. The interstices of the strand are completely filled up with Chatterton's compound. The gutta percha insulator is put on in four concentric layers of equal thickness, with a layer of Chatterton's compound between each layer of gutta percha. The electrical resistance of the insulator at 75 deg. Fah. is not less than 250 millions of British Association units after one minute's electrification. The finished core is capable of resisting the passage of water along the conductor, when a pressure of 600 lbs. per square inch is applied at one end of a specimen 6 in. long. Very great precautions have been taken by the manufacturers to prevent faulty joints, for it is at the joints that electrical leakage is most likely to occur. During all processes of manufacture the cable was kept as much as possible under water, and on board the Great Eastern the cable tanks are kept nearly full of water, so that the cable is completely covered.

The main cable from the island of St. Pierre to the United States. is 700 miles long, and will take a very indirect route, because of the inequalities and dangers presented by the bottom of the sea off the eastern coast of America. This cable being shorter and more easily recoverable in case of accident, is not of such good quality as contains a conducting strand of seven copper wires, weighing 107 lbs. per knot, and the insulator, of gutta-percha and Chatterton's compound, weighs 150 lbs. per knot. This core is served with tanned jute yarn, with a covering of ten BB galvanized wires, .165 in. in diameter, weighing about 4,254 lbs. per knot. It has an outer protection of hemp and asphalte, laid on in two coatings. The shore ends are of the same description as those connected with the main Atlantic cable; in all there are twenty-two knots of the heaviest shore end, and fifty-four knots of the lighter shore end to be used with the main cable connecting St. Pierre with the United States.

In accordance with the terms of the contract between the "Société du Cable Transatlantique Français, Limited," and the Telegraph Construction and Maintenance Company, Limited, the latter will receive in all £920,000 if they lay the whole line successfully, and it keeps in good working order for six months. But the greater portion of the above amount has already been paid to them. The following are the particulars:

First payment		£50,000
3,564 miles of cable at £164 per mile	£584,496	
On completion of manufacture,	504	
		585,000
Seven payments of £20,000 each, when each length of 500 miles was coiled on board		140,000
When the ship leaves Brest		35,000
On completion of the section between Brest and St Pierre (in fully paid shares)		80,000
On completion of the section between St. Pierre and the United States		10,000
Six months after the completion of the whole (in fully paid shares)		20,000
		£920,000

Directly the Great Eastern returns to England she will take fresh cable on board and start for India, to lay a line between Bombay and Suez.

STEEL CASTINGS.—Railway-wheels, anvil-dies, gearing, frogs, and many other heavy parts are now cast by Butcher and other steel makers, at much less than the cost of forgings, and with double the strength and nearly the smoothness of the best iron castings. From our extended experience with steel dies for steam hammers, and with steel gearing, we are prepared to express the belief that steel castings rank among the great economies of the day.

THE SUBMERSION AND RECOVERY OF SUBMARINE CABLES.

CONSTRUCTION OF THE FRENCH ATLANTIC CABLE.

From a paper read before the Royal Institution, by Professor FLEEMING JENKIN, F. R. S.

The speaker began by stating that his object was to explain the principles on which engineers had acted in laying and recovering submarine cables, rather than to exhibit the details of the machinery employed. The general construction of electrical cables was first described, and specimens were shown; especial attention being drawn to the deep sea French Atlantic cable, consisting of the following parts: A copper conductor, gutta-percha insulator, and jute serving, surrounded by ten wires of homogeneous iron, each served with five Manilla yarns saturated with tar.

TABLE I.

Construction of French Atlantic Cable—Deep Sea Section.

	Lbs. weight per knot.	Diameter in inches.	Breaking strain, lb.
Copper	400	.168	644
Gutta-percha	400	.463	...
Serving	234	.669	...
Homo. wires (10)	1,589	.100	950
Manilla strands (50)	1,091	....	550
Each served wire	268	.245	1,550
Cable	3,701	1.134	16,530
Weight of cable in air	1.652 tons per knot.		
" " water	.753 "		
Strength in tons	$7\frac{3}{8}$ tons.		

Table No. 1 gives the dimensions, weights and strengths of each of the component parts. The wire served with hemp will bear a greater weight than the sum of the weights borne separately by the wire and the strands; and, again, the ten served wires, when formed into a rope, bear a greater weight than the sum of the weights which each will bear. Moreover, while the homogeneous iron elongates less than one per cent before breaking, and the hemp elongates only .75 per cent, the two combined stretch 3 per cent. This paradoxical result is due to want of absolute uniformity in the strength of each part; when separate, each breaks at the weakest point; when combined, the weakest points seldom coincide; hence, the strength of the combination is the sum of the mean strengths of the parts, necessarily greater than the sum of the minimum strengths. The so-called spiral or helical form does not really render the cable elastic or liable to stretch, nor does it compress the the one to be laid across the Atlantic. It core inside the sheathing, as was shown by an experiment where the core was actually withdrawn without causing the collapse of the sheathing.

The manner of coiling the cable on board ship was explained by diagrams and models; it being shown that, in order to avoid putting a twist into the rope when taking it out of the hold, it was necessary to put a twist in when coiling it away. Bad coiling produces kinks or loops drawn tight, which are avoided by a cone filling the eye of the coil, and by rings or equivalent arrangements preventing the bight, as drawn out of the hold, from lashing out under the influence of centrifugal force.

The following table gives the dimensions and contents of the "Great Eastern" tanks as arranged for the Atlantic expedition. These tanks keep the cable under water on board ship to facilitate the electrical tests. They carry a weight of 5,000 tons in a bulk of 180,000 c. ft., the tanks not being filled quite to the top.

TABLE II.

	Diameter.	Depth.	Cable knots.
Fore tank......	51 ft. 6 in.	20 ft. 6 in.	728
Main tank......	75 ft. 0 in.	16 ft. 6 in.	1,100
After tank.....	58 ft. 0 in.	26 ft. 6 in.	912

Notwithstanding their enormous weight and size, these tanks occupy a very insignificant proportion of the whole bulk of the "Great Eastern."

Mr. C. W. Siemens has for light cables employed a sort of reel or drum on a turntable, with partial success, instead of the fixed tank and coil. From the tank the cable, when paid out, passes over a pulley and along a trough to the brake drum, the object of which is to restrain the free exit of the cable to such an extent as is desired. The cable is laid hold of by being passed several times round a drum, as a rope making fast a vessel may be seen to be passed round a bollard; the friction allows a slight strain at one end to prevent a very heavy pull at the other end from causing the rope to slip round the drum. The slight pull at what may be called the light end of the rope is given by a series of jockey pulleys which play the part of the hand when the rope is allowed to slip round a bollard, but, in paying out a cable the rope does not slip round a drum; the drum itself turns round restrained by a friction-band or belt.

It is essential that this restraining friction should be constant—a result obtained by the Appold brake, which was explained by models and diagrams. In this arrangement both ends of the brake strap are attached to one lever, in such a manner that when the drum begins to turn it tends to lift the lever and weight hanging to it, and as the lever is lifted it slackens the brake-strap until the difference of tension on the two ends of the strap is equal to the weight hanging on the lever. When this is the case, the lever is no longer lifted, but remains stationary with the strap, allowing the drum to turn, restrained by a constant friction equal to the weight on the lever. If the co-efficient of friction increases, the lever will be a little more lifted and the strap slackened; if the co-efficient of friction diminishes, the lever and weight will fall, tightening the strap; but in any case the retarding force will be simply equal to the weight.

From the brake-drum the rope dips under a weighted pulley, which rides, as it were, suspended on a V of taut cable; if the strain increases, the rope straightens and raises the pulley, if the strain diminishes, the weight and pulley fall; thus the height of the pulley indicates the strain. This instrument is called the dynamometer. Lastly, the rope passes over a pulley into the sea.

Having shown how the cable was treated, the speaker proceeded to show how the strains to be expected could be calculated. A cable paid out in air hangs in a catenarian curve, but in water lies in a straight line, and the strains in the two cases are wholly different. In air the rope meets with no sensible obstacle to its motion, either longitudinally or in a direction perpendicular to its own length; in water, on the contrary, each foot of a cable meets with an opposition to its motion perpendicular to its length, which we may call Q, and for the Atlantic cable

$$Q = .154\ v^2,$$

where v is the velocity of the cable normally to its own length in feet per second. Thus, as the cable weighs .2575 lbs. per ft., it cannot sink faster than the speed given by the equation

$$.2575 = .154\ v_1{}^2,$$

from which v_1, the settling velocity, is found to be 1.294 ft. per second, or .765 knot per hour. The result of this resistance to displacement is that the cable lies in a straight line, not in a catenary curve, supported, as it were, by an inclined plane of water constantly yielding at the velocity v_1. The inclination of the straight line depends on the velocity of the ship and on v_1 not being at all affected by the tension of the rope.

The angle ϕ at which the cable will lie may be calculated as follows: Let P be the resistance of the water to displacement by each foot of the cable of the weight ω when lying at the angle ϕ,

$$P = \omega \cos. \phi;$$

let v_{11} be the velocity at which the cable moves perpendicularly to itself,

$$v_{11} = v \sin. \phi,$$

where v is the velocity of the ship.

$$\text{Also } P = \omega \frac{v_{11}^2}{v_1^2};$$

$$\text{hence, } \cos. \phi = \frac{v_{11}^2}{v_1^2} = \frac{v^2 \sin.^2 \phi}{v_1^2},$$

$$\text{and } v_1 = \frac{v \sin. \phi}{\sqrt{\cos. \phi}}; \quad . \quad . \quad 1 \text{ deg.}$$

and, assuming that the resistance is proportional to the square of the velocity, we have $\omega = Q\, v_1^2$, and hence,

$$\frac{\omega}{Q} = \frac{v^2 \sin.^2 \phi}{\cos. \phi}, \text{ or}$$

$$\frac{\omega}{Q\, v^2} = \frac{\cos. \phi}{\sin.^2 \phi},$$

from which we have

$$\cos. \phi = \frac{\sqrt{\omega^2 + 4\, m^2} - \omega}{2\, m} \quad . \ 2 \text{ deg.}$$

where $m = Q\, v^2$.

From this formula, as indeed from common sense, it appears that the greater the value of Q and of v the smaller the inclination with the horizon. The rough Atlantic cable, when the ship was going at the speed of six knots per hour, lay at an angle of $6\frac{3}{4}$ deg., so that the inclined plane was seventeen miles long, and each foot of the cable took nearly three hours to reach the bottom.

The strain T at the top of the inclined plane, if there were no friction preventing the rope from slipping back along the plane, would be equal to the weight of a piece of cable hanging plumb from the surface of the water to the bottom, or

$$T = \omega\, x,$$

where ω is the weight per foot run of the cable and x is the depth in feet.

But there is a sensible friction which helps to relieve the strain precisely as when a chain is lying on a solid inclined plane; calling m_1 the co-efficient of friction in pounds per foot length of cable at the velocity v in feet per second, and assuming that $m_1 = Q_1\, v^2$, the experiment of the Atlantic cable showed that $Q_1 = .00504$ (this is equivalent to .81 cwt. per knot of cable when slack is paid out at the rate of one knot per hour). The result is, that when slack is paid out, say at the rate of one knot per hour, and when $\phi = 6.45$ deg., the strain is diminished by one-half, and if slack were paid out at the rate of 1.4 knot per hour, or $23\frac{1}{2}$ per cent, this particular cable would require no retarding force whatever.

The strain T_1, when the velocity of the cable is v_{111}, can be found from the following formula:

$$T_1 = \omega\, x - m_1 \frac{\left(\frac{v_{111}}{v} - \cos. \phi\right)^2}{\sin. \phi} x \ldots . 3 \text{ deg.}$$

Cables of light specific gravity have a small settling velocity and lie at great length in the water, and, if they are also rough, the co-efficient Q_1 may easily be so great as to relieve the brake of most of the strain which would be necessary to lay a cable of equal weight but small bulk and smoother surface, with the same amount of slack. If no slack were laid, there would be little difference between the tension required for cables of different construction but of equal weights in water. When much slack is laid, all cables will be considerably less strained than if laid without slack; and, finally, the faster the ship goes the less slack is required to produce any given amount of relief.

The correctness of the above theory has been amply proved in practice. If in seas 2 miles deep the cable hung in a catenary $12\frac{3}{4}$ miles long, the weight to be carried would be $8\frac{1}{2}$ tons, and the strain on the cable 29 tons; while, if the cable hung in a catenary the inclination of which to the horizon at the stern was 9 deg. 30 min., the length would be 24 miles, the weight 17 tons, and the strain 102 tons instead of about 14 cwt.—the strain actually observed for the Atlantic cable when being paid out at 7 knots per hour while the ship was going at 6 knots per hour. The rise and fall of the ship, even in heavy weather, very slightly affects the strain while paying out, on account of the slight inclination of the cable to the horizon. The margin of strength in deep sea cables of the Atlantic type is even greater than is given in most engineering works, since the cable will bear tenfold the strain which is found necessary in laying.

The process of grappling was next described, and the operation illustrated, by dragging a miniature grapnel over the floor, so as to hook a chain lying there. When the cable is hooked, the strains of the grapnel rope are simply the weights of the bight lifted, and the length of this bight depends on the slack. Thus, with 14 per cent of slack, the length of the cable lifted will be 4.89 times the depth to which it is raised. Thus, in two miles of water, about 9.8 miles of cable will be lifted, the weight on the grapnel will be 6.86 tons, but the strain on the cable will be only one component of this weight resolved in the direction of the tangent to the curve at the grapnel; this strain will be 5.5 tons. Thus, it is clear, that in calm weather, with 14 per cent slack, the cable can be lifted from a depth of two miles. This was actually done upon one occasion; but owing to the pitching of the ship the cable parted, and we successfully recovered by the obvious device of grappling the cable in two points about $2\frac{1}{2}$ knots apart, and breaking the cable at the point furthest from land; the loose end then hung down over the other grapnel, and it is obvious that by this plan the strain on any cable in any depth can be limited to the simple weight of a length of cable hanging from the surface to the bottom. The Atlantic cables will bear five times the strain due in this manner to two miles of depth, and for this operation the margin of strength is also ample. The cable is hauled in by machinery very similar to that adopted for paying out; the drum being simply turned in the opposite direction by a steam engine, if only a small length is to be picked up. If many miles are required, the cable is transferred to the bow, and hauled up by a double drum to avoid the fleeting necessity on a single drum. The friction on the water during the operation adds to the strain; thus, with the valve of Q_1 previously found, at one mile per hour, the friction per mile would be .81 cwt., adding in a depth of two miles 1.61 cwt. to the strain due to the simple weight; besides this, there is some resistance due to the displacement of the water, by the bight of the rope at the bottom, and some extra weight due to the fact, that the cable hangs in a catenary, not in a straight line. The length of this catenary depends on the rate at which this cable is hauled through the water; but even after allowing for all these things the strength of the cable is from three to four times greater than the strain which, in fair weather, need come on the cable when being picked up from a depth of two miles—a margin of strength not unfrequently adopted even in permanent engineering works.

It was by calculations like these, that before the 1865 cable had been recovered in 1866, the speaker was able to write in "The Times," of August, 1865, "If the cable retain its strength, as it probably will, it can certainly be raised;" and now that experience has confirmed theory, engineers are justified in looking forward with great confidence to the continued prosperity and extension of deep-sea telegraphy. The following tables give some further information as to the French Atlantic cable about to be laid, which will cover fifty acres of ground, being a narrow strip, 3,564 knots long, and a little more than an inch wide.

TABLE III.

Lengths and Weights of Materials used in French Atlantic Cable.

	Knots.	Tons.
Copper wire	24,948	533
Gutta-percha	3,564	549
Jute serving	......	500
Homo. wire	27,222	1,872
Iron wire	9,941	2,855
Total iron and homo. wires	37,163	4,727
Manilla strands	136,110	1,286
Clark's compound	881	652
Deep-sea cable	2,643	4.366
Shallow-water cable	921	3,881
Total cable	3,564	8,247

TABLE IV.

Lengths of Existing Cables.

	Knots.
Atlantic (two)	3,748
Malta, Alexandria (two)	2,254
Persian Gulf	1,308
Home seas	1,277
Miscellaneous (approximate)	1,350
Total	9,937

THE MAST HOPE DISASTER.—Nearly every railway disaster can be traced to bad or worn-out plant and machinery. But after all the modern refinements of materials and construction have been applied, there come to us, about twice a year, the ghastly details of a wholesale murder by the very refinement of stupidity. A misplaced switch, the absence of a signal behind a stopped train, running into a drawbridge, and, sublimest of all, colliding with a train supposed to be on a siding; this is manslaughter, and must be punished as such. No hidden defects in materials or construction can excuse it.

WHEEL-BASE OF RAILWAY VEHICLES—SAFETY OF THE AMERICAN TRUCK.

Although the practice with our common "spread" truck has been remarkably successful, there appears to be something for English engineers to say on the other side of the question, for instance, the following, from a correspondent of "The Engineer," with reference to an article on railway safety which we have quoted from that journal on another page.

The bogie is, in fact, a means of reducing the wheel-base without reducing the length of carriage-body; and the object of this reduction of wheel-base is to diminish that obliquity of the axles which results from their fixed parallelism. This obliquity, in the case of a four-wheeled truck standing centrally between the rails, is well known to be directly proportional to the length of wheel-base, and the conclusion appears to have been jumped at that the shorter the wheel-base the less the obliquity. But the consideration seems to have been overlooked that this obliquity is liable to an increase from the turning of the truck about the bogie-pin until the diagonally opposite wheels touch the rails with their flanges, and that the angle through which the truck can thus turn is *inversely* proportioned to the wheel-base. It is true that while this increases the obliquity of one axle, it diminishes that of the other; but this is no abatement of the damage, since it is the greatest obliquity of any axle that measures the tendency of the truck to leave the rails or burst the track. And this turning of the truck about the bogie-pin, if it be not brought about by chance oscillations, producing the wriggling or "wobbling" which you describe, is certain to be pushed to its extreme limit in one direction, during the passage of curves, by the action of a couple resulting from the resistance of the wheels to being slipped or skidded as they must be to compensate for the inequality of their paths. Now in English stock coupled tightly together, not only are the chance oscillations checked and absorbed by opposing the mass of one carriage to the impetus of its neighbor, but the couple above referred to is neutralized by the action of the same couple in the next carriage; while the American bogie, free of all restraints, is left to wriggle and wobble at its own sweet will.

Leaving this out of account, however, and considering that the possible angle of obliquity of the leading axle is, as above stated, the sum of two angles, of which one is directly and the other indirectly proportional to the length of wheel-base, it is clear that a truck may have too short as well as too long a wheel-base for the safe transit of a given bit of road, and that *there is a length of wheel-base which will give a less obliquity of axle than any other, shorter or longer.* The determination of this length and the calculation of the angle of obliquity for any given case is a simple matter; and it will be easy to demonstrate that there are circumstances of common occurrence under which an ordinary English carriage will traverse a sharp curve with less obliquity of axle than an American bogie.

Thus, the sine of the angle of obliquity caused by parallelism of axles is $= \frac{l}{2r}$, l being the length of wheel-base and r the radius of curve; and as the angles will in any case be small, we may say that this is approximately = the circular measure of the angle. The circular measure of the angle through which the truck can turn in either direction is approximately $= \frac{s}{l}$, s being the play of the flanges, i. e., gauge of rails minus gauge of wheels outside flanges. Thus the obliquity of axle $= \frac{l}{2r} + \frac{l}{s}$.

And the length which will give the smallest angle of obliquity is $= \sqrt{2r\,s}$

Now let us take a 10-chain curve for example; and as the gauge is sure to be widened on such a curve, and we have to take the *worst case*, it will not be too much to assume that s may be = 1 in. Then using the above formulæ, we find that the best length of wheel-base, or that which gives the least obliquity of axle in this case is about 10 ft. 6 in. (an ordinary English carriage), while *an American bogie of 5 ft. wheel-base would actually present its leading axle at as great an angle of obliquity as a carriage with 22 ft. wheel-base.* On flatter curves, supposing the play to remain the same, the disadvantage of the short wheel-base is even more apparent.

The conclusion to which we are driven, then, is that though on sharp curves a long wheel-base is dangerous, yet the difficulty is not to be obviated by shortening it, because of the unsteadiness thereby induced; and the only satisfactory solution of the problem will be by some simple arrangement by which the wheel-base may be maintained of any desired length, and the axles truly radiated to the curve.

VELOCIPEDES.

From "Engineering."

We have for a long time excluded the subject of velocipedes, as one of diminutive carriage building, from the pages of "Engineering"; but they have in the mean time become articles of extensive manufacture by large and long established firms of mechanical engineers, railway carriage builders, and others. In Birmingham, for example, at least three eminent firms are engaged in making, by scores, if not by hundreds, what, a year or two ago, were thought to be little better worthy the attention of engineers than Bath chairs or perambulators. The principal of a velocipede—and with all their alleged differences velocipedes are much alike—is a little paradoxical to those who consider it for the first time. How is it that they can stand upright on two wheels only, one trailing behind the other? And how is it that the rider can accomplish fifty miles as easily, if not easier, than eight or ten miles of walking? As to the first question, the principle is the same as that which keeps a boy's hoop upright as long as it is kept in rotation, the tendency of all revolving bodies to continue in revolution in the same plane as that in which they were first made to revolve. With internal propelling mechanism, a velocipede might run by itself, the rider, who once puts it into motion, has only to preserve his own balance, and not that of the machine *per se*, which, once equilibrated on both sides when at rest, will take care of itself when in motion.

As to the reason why there is less fatigue in working a velocipede than in walking, a little examination is necessary. Whatever the weight of the velocipede and rider, it is a rolling weight only, and the resistance to rolling, at, say, ten miles an hour, will not much exceed one-fortieth of the weight when this is moved over a smooth, level road. Taking the total weight as 210 lbs., or, say, 15 stone, the rolling resistance would be but $5\frac{1}{4}$ lbs., and as a muscular man can easily, for an hour or more, and under the exhilarating influence of a race, work up to at least 4,620 foot-pounds per minute, this would correspond to an advance of 880 ft. per minute, or ten miles an hour. The late Mr. Glynn's work on cranes quotes instances of a much greater exertion of human strength for short intervals, in some cases nearly 30,000 foot-pounds per minute, or much above the average power exerted by an ordinary horse, and nearly equal to the standard horse power of the engineer. The writer himself, weighing 180 lbs., has often raced up a circular staircase of fifty-six steps, and rising 32 ft. 6 in., in thirteen seconds. Were this rate continued (not that he could so long continue it) for even a minute, it would correspond to the exertion of 27,000 foot-pounds in that time. One-sixth of this work, or 4,500 foot-pounds per minute might, probably, be continued for a considerable time, and this would carry him and his velocipede at nine or ten miles an hour on a good level road. The force would be exerted in the latter as in the former case by the great extensor muscles of the legs, the weight of the body being wholly carried on the velocipede, instead of being lifted as on the staircase.

In walking, muscular strength is expended in alternately lifting, by either leg, its fellow leg, and the weight of the whole body above both legs, through a distance, at each step, corresponding (were there no "spring" to the feet) to the rise of the arc described by the body in swinging over either leg upon a fixed unyielding fulcrum at the foot. The beautiful mechanism of the foot, of itself, takes off a good part of this lift, but neither the head nor any portion of the body advances in a truly horizontal line when walking, this being the case only in rolling along a level plane. There is, too, the irregularity of advance of the body, which is accelerated and retarded at each step to give time to "change legs," and there is the power expended in moving the legs themselves, considered as weights, to be stopped and started at every step. In this way, together with the strain imposed upon the muscles of the legs in the mere statical support of the body, as much fatigue may be occasioned in an hour's walk of three miles as in a spin on a velocipede at three or four times the speed.

And the bicyclical contrivances appear to possess a commercial value in their use. At any rate we hear of a firm of mechanical engineers who assert that they save 40s. weekly on an average, in cab fares, messengers, &c., by retaining a sharp velocipedestrian as a means of communicating between their two establishments, less than half a mile apart, a private telegraph being unavailable for the transmission of drawings, parcels, samples, daily accounts, &c.

TRANSMITTING POWER BY ROPES.

From "Belting Facts and Figures," by J. H. Cooper, in the "Journal of the Franklin Institute."

Among the more recent improvements in the way of *transmitting power* for long distances, is the substitution of belts by endless wire ropes, running at a high speed; their use bids fair to add immensely to our manufacturing facilities. The distance to which you can thus transfer power ranges from 75 ft. to 4 miles. Just where the belt becomes too long for economy, there the rope steps in. In place of a flat faced pulley, a narrow sheave with a deep flaring groove is used, the groove being filled out, or lined rather, with leather, oakum, india rubber, or some other soft substance, to save the rope. The essential points are a large sheave, running at a considerable velocity, and a light rope. When the distance exceeds 400 ft., a double grooved wheel is used, and a second endless rope transmits the power 400 ft. further, and so on indefinitely. The loss by friction is about 8 per cent per mile. A few examples may prove of interest, and give information.

It is required to transmit 300 horse-power by means of a wire rope. A wheel $14\frac{1}{2}$ ft. diameter, making 108 revolutions per min., is sufficient; the rope running at a rate of 4,920 ft. per minute—size of rope required, one inch diameter. The distance has nothing to do with it. Again: "It is desired to transmit for any distance as much power as a 12 in. belt will give." Assuming that the belt travels in the neighborhood of 1,300 ft. per minute, it is about equivalent to 20 horse-power, and a grooved sheave of 7 ft. diameter, running 100 revolutions per min., with a $\frac{5}{8}$ in. rope, will be the proportions required. Again, a 4 ft. wheel, running 100 revolutions per minute, with a $\frac{3}{8}$ in. rope, will convey from 4 to 5 horse-power. The cost of the rope is always the smallest item, amounting to a few cents per foot, and not one-tenth the cost of an equivalent amount of belting. One is thus enabled, at a small expense, to transmit power in any direction; for instance, to a building lying remote from the main factory buildings, where it is not worth while to put up a separate engine. Across rivers, creeks, canals, streets, over the tops of houses, under water, from cellar to roof, etc.

Frequently an excellent site for water power remains unimproved for want of suitable building sites in the neighborhood. The water may be conveyed *down stream* by means of expensive canals and flumes; but by a wire rope transmission we can transfer it in any direction, either up stream, across it, or sidewise, up and down grades of one in eight—in fact, anywhere. "In many sections of our country coal is dear and water power plenty, but not improved, for reasons which may be set aside by the above method. In Europe over a thousand factories are driven in that way."—*The Manufacturer and Builder*, Feb. '69, p. 38.

In a paper by Mr. John Ramsbottom, in "Newton's Journal," vol. XXI, p. 46, on traversing cranes at Crewe Locomotive Works, dated January 28, 1864, mention is made of the means by which power is communicated from the shop lines of shafting to the gear of the cranes. It consists of a $\frac{5}{8}$ in. diameter soft, white cotton cord, weighing about $1\frac{1}{2}$ ounces to the foot, running at the rate of 5,000 ft. per minute, in a line with the longitudinal motion of the crane, above the same and over a 4 ft. diam. tightener sheave. This sheave is weighed so as to put a tension on each strand of the cord of 108 pounds, which is found to be the best working strain for keeping the rope steady, and giving the required "hold" on the main driving pulley. The cranes have a span of 40 ft. 7 in., a longitudinal traverse of 270 ft., and the rails are 16 ft. above the floor. The cord is supported every 12 or 14 ft. by cast iron fixed slippers of plain cross section, $1\frac{5}{8}$ in. wide, with side flanges. These slippers are placed $1\frac{1}{2}$ in. below the working line of the driving side of the cord, so as to allow the driving wheels on the traverser to pass them; they are not oiled, and the friction of the cord in them amounts to two-fifths of the working load.

Motion is communicated to the gear of the crane by pressing the cord into grooved cast iron pulleys. The grooves in the driving pulleys are V shaped, at an angle of 30°, and the cord does not touch bottom; the guide pulleys have circular grooves, same diameter as the cord, and the pressure pulleys have a circular groove of larger diameter than the cord. The driving pulleys have a diameter equal to thirty times the diameter of the rope. Guards are put on the pulleys to keep the ropes in. The driving power of the cord to lift 25 tons is only 18 pounds, irrespective of friction, which is a ratio of 3111 : 1. Light loads are about 800 : 1. In the gib cranes, driven by similar means, the ratio is 1000 : 1 when lifting 4 tons at the rate of 5 ft. $1\frac{1}{2}$ in. per minute. The actual power required to lift 9 tons, besides the snatch block and chain, has been found to be 17 pounds at the circumference of the driving pulley. The crab, when unloaded, requires $1\frac{1}{8}$ pounds to overcome its friction. The cords are soon reduced to $\frac{9}{16}$ in. diameter, and last about eight months at constant work. In an overhead traverser, used in the boiler shop, lifting six tons, three years in use, a $\frac{5}{8}$ in. cord was employed, but was afterwards changed for a cord $\frac{1}{2}$ in. in diameter. The light driving cord is the only plan compatible with high speeds; a heavy chain, belt or cord, would soon wear out and break by its own weight.

THE CENTRAL RAIL.

From "The Engineer."

The really successful thing, and perhaps the only complete success, on the Mont Cenis Railway is the central rail. Without even stating that the central rail is absolutely required, if we merely consider the tractive force required on the Mont Cenis, it seems to us to be the most important innovation in locomotive work that has been made during the last twenty years. It is the only means yet discovered of obtaining adhesion without increasing weight, or without that adhesion being dependent on weight for its existence. Apart from the plan of applying powerful electro-magnets to the wheels, which has not been found to answer, though tried more than once; and the fixed rope scheme of Mr. David Greig—avowedly only a substitution for the central rail—the central rail constitutes the only system yet conceived for working a locomotive independently of the adhesion obtained by its weight. It is remarkable how difficult locomotive engineers, even of great ability, find it to disconnect in their minds great tractive power with the rail-adhesion produced by the actual weight of the engine bearing on the driving and coupled wheels. With ourselves it has always seemed a mechanical absurdity to provide weight in order to get the power to lift it up and carry it along. With all the wheels coupled together the maximum obtainable adhesion is obtained; but there is practically no limit to the amount to which the horizontal wheels in the Fell engine can be brought to clip the central rail. The central rail again offers a comparatively immense amount of security against running off the line, and an admirably speedy and safe means of braking the train on a descent. Certainly, when looking down the precipices passed by the Fell trains, without the knowledge of the use of the central rail we should scarcely have felt unconcerned and comfortable. The force of the wind also on these mountain passes is sometimes so tremendous that the extra protection and hold afforded by a central rail is an absolute necessity.

Working with a central rail has more than once been proposed during the last forty years; but in great improvements, not merely the man, but also the hour, must come together. Vignoles and Ericsson patented in 1830 the central rail with very different motives and views to Fell, and certainly not with the intention of getting an engine and train over such sharp curves and steep inclines as those on the Mont Cenis. An American engineer, however, not merely patented the plan in England, but actually carried it out for a short time in America, though he afterwards dropped it, proving that he had not that faith in the plan which he might have had if he had fully understood its importance.

It would not be fair to compare the central rail with schemes which have never been tried. The heavy Engerth engines on the Semmering have scarcely been a success, either in themselves or in their effects on the permanent way. What is the result of some of the very best practice in the kingdom when seeking to obtain greater adhesion from actual weight? On the Metropolitan Railway, engines weighing about forty-two tons have to be employed to draw trains weighing about eighty tons. In this there seems to be a sort of mechanical contradiction of terms. Mr. Fell's engines have been stated by Mr. Brunlees to weigh only sixteen tons, and putting twenty-four tons pressure on the horizontal wheels, plus the weight of the engine itself, the co-efficient of adhesion of one-fifth gives a total adhesion of one-half the weight of the engine. It must also be borne in mind that when people speak of getting on an ordinary line of rail an adhesion of one-fifth, or even more, of the load, they tacitly assume the rails to be in good condition. With rails in bad condition it is believed by engineers of the highest standing that whatever may be the weight of the engine, the wheels are liable to slip. There is also special reason on this line why, apart from other causes, an extra amount of adhesion is required. It appears that on the Mont Cenis a fine dust of a most lubricative nature is blown down upon the rails in dry summer weather. This is the dust of the schistose rock of which the road—which is still partly used for ordinary traffic—is mended, and when wetted besides, the rails are sometimes in a worse condition for adhesion than from the snow in winter.

It is not perhaps impossible that such light loads as those now taken up Mont Cenis could be taken without the central rail; and certainly this might be done *if* the line were straighter—but whether with as much safety is another and a very different question. Suppose, then, we assume it as proved that the adhesion produced by weight alone would carry a remunerative load up a gradient of 1 in 10 or 12, how about passing such sharp curves as there are on the Mont Cenis? In the first place, the central rail diminishes the friction in passing round very sharp curves; and the wonder is even witnessed on the Mont Cenis that sharp curves are passed more easily than the straight line in an ordinary line, the resistance to traction on a curve of only 400 ft. radius has been estimated as *double* the resistance on a straight line on a level. And there has been no instance of an engine running off this line—no small advantage with a precipice on one side of you thousands of feet deep.

In fact, the wonder in passing the Mont Cenis is not so much at the tractive power of the engine—as the load is but slight—but the ease with which the train winds its way over a serpentine road, passing over curves of little more than five or ten chains radius. The horizontal gripping wheels of the engine, and the horizontal guide-wheels of the carriages, keep the train true on the line, and prevent much of the usual prejudicial action from coming into play. Just as the adhesion is practically unlimited, so is the brake power in descending the steep gradients. On such a difficult line as an Alpine line—whereon, in winter, guards have to be placed to warn as to descending avalanches—the ease whereby a train can be stopped is of the greatest necessity. We think that very few disinterested people can come to any other conclusion than that, on such lines, with such complicated conditions, differing so much from our own, the central rail system is the only one to be depended upon for tractive and brake power, flexibility round the curves, safety to life, and practicable cheapness. It seems to us not impossible that we should have an approach to perfection in a sort of combination of the engines advocated by M. Thouvenot and Mr. Fairlie with the central rail. Of these two tank-engines, placed back to back—united as to their fire-boxes and boilers—one pair of cylinders could work the four coupled wheels of one bogie-frame in the ordinary way, and the other pair could be set to work the gripping wheels on Fell's plan on the second frame. With such a combination there need scarcely be a single piece of gear more than if only vertical driving wheels were used.

Goods Engines for Steep Inclines.—The Paris, Lyons and Mediterranean Railway Company will work the steep inclines of the new branches now in progress with eight coupled engines of a new pattern. Twelve engines of this system are being manufactured at the Graffenstaden Works, at the price of £52 8s. 3d. per ton, but the working drawings were prepared in the offices and by the engineers of the company. These engines have fire boxes overhanging the rear drivers, and outside cylinders. The valve gear is also outside, the eccentrics being supported by an overhang to the end of the crank pin of the driving axle. The frames are curved transversely to clear the fire box, which is of unusual width. The curved part of the frame is strengthened by a strong wrought iron bracket, a contrivance which has been used with much success by the Eastern Railway. The first and fourth axle have an end play of 1 in. in the brasses, and spherical crank pins for the coupling rods, enabling the engines to pass easily round curves 720 ft. radius; all the wheels are, of course, flanged. The engine is suspended by eight springs and four compensating beams. The boiler is fed by a single injector, connected through two india rubber pipes to a tender, which has nothing worth noticing, and weighs about twenty tons in working order. The engines, as well as all the other engines of the company, are fitted with the Lechatelier reversing arrangement, and Thierry's smoke-consuming apparatus. The following dimensions of the most important parts of these engines are from "The Engineer."

Fire grate.

	ft.	in.
Length	5	1
Width....................	4	$5\frac{1}{5}$
Surface in square feet	$12\frac{1}{3}$	

Inside fire box.

	ft.	in.
Height next the tube plate.....	5	$10\frac{1}{5}$
Height next the door	5	$4\frac{2}{5}$
Inside width at the top...	4	$2\frac{4}{5}$
Inside width at the bottom	4	$5\frac{1}{5}$
Inside length at the top........	4	$6\frac{4}{5}$
Inside length at the bottom	5	1

Thickness of fire box, copper.

	ft.	in.
Door plate		$\frac{3}{5}$
Side plate...................		$\frac{3}{5}$
Top of tube plate		1
Bottom of tube plate..........		$\frac{3}{5}$

Tubes.

	ft.	in.
Number 244		
Outside diameter		2
Length	17	7
Heating surface of fire box (sq. feet).....................106		
Heating surface of tubes in sq. feet.....................2,132		
Total heating surface in sq. ft., 2,238		

Outside fire box.

	ft.	in.
Length at the top	5	$3\frac{4}{5}$
Length at the bottom	5	$7\frac{4}{5}$
Width	5	$0\frac{3}{5}$
Thickness		$\frac{16}{25}$

Boiler.

	ft.	in.
Diam. outside of smallest plate..	4	11
Length	17	3
Thickness		$\frac{16}{25}$
Height of the center above the rail	6	$6\frac{2}{5}$
Steam pressure ....125 lbs.		
Diameter of each safety valve ..		$5\frac{1}{5}$

Chimney.

	ft.	in.
Diameter....................	1	9
Height above the rail	14	4

Frames.

	ft.	in.
Inside distance at the front	3	$11\frac{3}{5}$
Inside distance at the back	5	$10\frac{1}{5}$
Thickness		$1\frac{1}{5}$
Total length of the engine.....	32	2

Wheels.

	ft.	in.
Diameter	4	$1\frac{3}{5}$
Distance of axles.............	4	$5\frac{1}{5}$
Total wheel base	13	$3\frac{3}{5}$

Miscellaneous.

	ft.	in.
3d axle		8
1st, 2d and 4th		$7\frac{1}{6}$
Length of journals............		10
Diameter of cylinders	1	$9\frac{1}{5}$
Stroke......................	2	2
Length of connecting rods	8	$4\frac{2}{3}$
Distance between centers of the cylinders..................	6	$13\frac{2}{5}$
Angle of advance of eccentrics, 35 deg.		
Throw of eccentrics		$2\frac{4}{5}$
Stroke of slide valve in full gear		$5\frac{3}{5}$
Inside lap of slide valves		$\frac{1}{50}$
Outside lap of slide valve......		$1\frac{1}{6}$
Average admission in full gear..		$\frac{4}{5}$
Length of steam and exhaust ports	1	$2\frac{1}{5}$
Width of steam ports		$1\frac{4}{5}$
Width of exhaust ports........		$3\frac{3}{5}$
Number of spring plates.......	11	0
Width		$3\frac{3}{5}$
Thickness.		$\frac{1}{2}$
Length	2	10
Camber		$3\frac{1}{5}$
Distance of center of gravity in front of 3d axle............	2	$0\frac{2}{3}$
Total weight of engine empty .. 43 tons.		

Distribution of weight in working order.

	tons.	cwt.
1st axle......................	12	0
2d axle	12	0
3d axle	12	13
4th axle	12	13
Total weight............ .	49	6

These engines are especially designed for working steep inclines at very small speed. A single engine will easily take, at ten miles an hour, a 200-ton train up an incline of 1 in 40, or better, two engines, one at the front and the other behind, will work a 400-ton train. With so small a speed the overhang of the fire box and the end play of the leading and trailing axle are without any practical inconvenience. The company do not intend, of course, to work their main lines with these engines, where the speed is much greater, and where the six-coupled engines now in use are quite sufficient.

British Heavy Guns.—In a recent article, the London "Times" drew attention to the comparative trials for endurance of 9-in. guns now in progress at Woolwich. It was stated that one pattern of the Woolwich coiled wrought-iron gun had endured 400 rounds with ordinary service charges of 30 lb. English large-grain cannon powder, and 714 rounds with battering charges of 43 lb.; in all, 1114 rounds—a test far beyond anything that such a gun could probably be called upon to resist even during a great war. The gun remains perfectly serviceable. The gun and its ammunition were calculated for each other, regard being had both to power, endurance, weight, and cost; and that there may be no mistake as to the powers of the Woolwich 9-in. gun, with battering charges of 43 lb., we give the maximum penetrations which the gun is capable of effecting, as laid down by the Committee on Fortifications: into earth 40 ft., into concrete 12 ft., into brickwork 12 ft., into rubble masonry 8 ft., into massive granite 2 ft. (but with fracturing and disintegrating effect to a much greater depth, and over a considerable area), into iron plating 11 in. Well-trained gun detachments can, if the circumstances are not unfavorable, load, aim, and fire the 9-in. gun at the rate of one round per minute, so that a six-gun battery could deliver a shot or shell well aimed every 10 seconds.

The difference between the second or ordinary pattern of the Woolwich gun and its predecessor under trial consists in certain details of construction. The first trial gun had a steel tube only 2 in. thick, the second a 3-in. tube. In the first the coils intended to form the breech of the gun were made up in two masses, so that the breech consisted of two layers of wrought iron over a thin steel tube. In the second the whole of the wrought iron covering the breech of the tube had been previously welded up into one mass, so that the breech consisted of one layer of welded coils over a thick steel tube. The result has been in favor of the gun with less steel and more iron disposed in two layers. The endurance of both pieces has been eminently satisfactory.

The second gun has fired 400 rounds with 30 lb. charges, and 649 with 43 lb. charges—1,049 rounds in all. During the firing of the 400 charges of 30 lbs. and during 207 of the 43 lb. charges, the vent was in rear of the usual place. The last 442 rounds with 43 lb. were fired through a vent in the ordinary service position, which is more severe upon the gun. The piece is now unserviceable, but became so by a most gradual and easily watched process. About 200 rounds before the end of the trial a flaw was detected in the steel tube. It developed gradually, though the steel barrel is tightly gripped by the wrought-iron exterior, up to the 1002nd round, when gas was discovered escaping from the indicator hole—a small orifice bored in all our heavy guns to give notice when a steel tube is cracked through. The proof was continued with full battering charges until, at the 1049th round, the steel tube shifted forward about 2 in. and closed the vent, so that further firing became impossible. Thus, though the gun is unserviceable, it has stood an enormous test, and yielded slowly at last, step by step. We need hardly say that no accident could possibly have happened to any one. Cases, very few and far between, might possibly occur of a Woolwich gun bursting at proof if the steel tube happens to be exceptionally bad, because the proof charge is inordinately large. We have known one such case. Indeed, the proof is intended to test thoroughly every part of a gun, not merely the interior. This trial was merely comparative; but, while it has shown the advantage of using thin interior steel tubes or barrels in preference to thicker ones, it has also shown that Woolwich guns, made on either pattern, are capable of an endurance entirely unknown among the expensive heavy guns possessed in extremely limited numbers by Continental powers.

TESTING STEAM ENGINES.

From "Engineering."

Although the ordinary method of expressing the performance of a steam engine by stating the number of pounds of coal per horse power per hour consumed in working it, no doubt possesses some points of practical convenience, yet as a means of comparing accurately the performances of different engines it is absolutely valueless. That this is the case will be readily admitted when it is considered that the number of pounds of coal consumed per horse power per hour by any given engine may be varied within very wide limits without the engine itself being modified in any way. Any given engine working at a given speed, under a constant load, and supplied with steam at a constant pressure, will, so long as no derangement of its parts takes place, consume a certain constant quantity of that steam per hour; but, on the other hand, the amount of fuel consumed in generating this quantity of steam may vary considerably according to the description and proportions of the boilers used, the quality of the coal burnt, the care and skill exercised in stoking, the means adopted to prevent loss of heat by radiation, and other details which it is unnecessary that we should mention here. It thus follows that a bad engine supplied with steam by an economical boiler worked by skillful stokers may, according to the ordinary method of estimating performance, show as good a result as an engine which is in reality very superior to it, but which draws its supply of steam from boilers of less efficient proportions, or less carefully fired than those of its rival, and this although the same quality of coal is used in the two instances. Even if the two engines are supplied with steam from boilers of the same class fired with equal care, the comparison is rarely a perfectly just one; for with all boilers there is a certain rate of evaporation at which the consumption of fuel per pound of water evaporated is less than at any other, and it may—and in practice probably always will—happen that the supply of steam needed by the one engine will approach more nearly to this rate of most economical evaporation than that required by the other, and hence an inequality of which it is impossible to estimate the amount with accuracy. The fault, in fact, of the ordinary system of estimating steam engine performance is that it considers the engine and boiler as a whole instead of regarding them as two entirely independent parts, either of which may be good or bad without in any way affecting the efficiency of the other.

A better measure of the efficiency of any given engine than the number of pounds of coal consumed per horse power per hour in supplying it with steam, is the weight of that steam as estimated from the quantity of water evaporated by the boiler. We say *estimated* advisedly, for there are but few boilers which do not prime to some greater or less extent, and the amount of this priming will, of course, always cause the apparent evaporation to be somewhat greater than that which actually takes place. The practice of estimating the efficiency of an engine by the quantity of water consumed by it, has, however, never become a general one, and there are abundant reasons why this should be the case. To ascertain accurately the quantity of water consumed per horse power developed by any given engine is practically no very easy matter. In the first place the power exerted by the engine during the trial must be constant—or so nearly constant that the mean power exerted may be accurately estimated—and this is a condition which, except in the case of engines employed for pumping water and a few other instances, is very difficult of attainment for any lengthened period of time. Next, the quantity of water supplied to the boilers must be accurately ascertained, not by water-meters, which are rarely thoroughly accurate, but if possible by direct measurement in a tank or equivalent contrivance, allowance being made for variations of temperature; thirdly, care must be taken that no steam is taken from the the boiler for other purposes than supplying the engine, and that there is no leakage from valves, cocks, etc.; and fourthly, the water level in the boilers should be the same at the termination of the experiment as at its commencement. In the case of marine engines also with boilers worked with salt water, of which a certain proportion has to be blown off at intervals, the amount thus blown off would have to be ascertained. Altogether such experiments require not only careful, but skilled superintendence; and as, to be of practical use, they must be of lengthened duration in order that inaccuracies due to variation of water level, etc., may be as much as possible eliminated, they are necessarily expensive to carry out, and are consequently seldom resorted to.

Having stated the errors and inconveniences incidental to the ordinary methods of comparing the performances of steam engines, it is only fair that we should point out a method of making such comparisons to which the above mentioned objections do not apply. This method is a very simple one, and consists merely in measuring the heat carried off from the engine by the exhaust steam, this steam, this heat being, in the case of a condensing engine, of course imparted to the water used for effecting condensation. It has long been a practice with many engine-drivers to roughly estimate the temperature of the water in the hot wells of their engines, by dipping their hands in it, and in this way to get some rude idea of the manner in which their engines are working; and several engineers, and amongst them Mr. David Thomson, have by supplying an engine with a constant amount of condensing water, and noticing the variations in the temperature of the latter estimated the relative economy of different rates of expansion etc, when working against a given load. The merit, however, of reducing this method of testing engines to a system, and devising means for carrying it out in a simple yet thoroughly accurate manner is due to Mr. B. W. Farey and Mr. Bryan Donkin, jun., of the firm of Messrs. Bryan Donkin and Co., of Bermondsey, who have during the past eighteen months or so ascertained the performances of a number of engines in this way both in this country and abroad. In a letter addressed to us, and which was published in Engineering of the 17th of July last, (*vide* page 58 of our last volume), Mr. Farey drew attention to this mode of testing engines, and gave a description of the apparatus employed; but it may nevertheless be convenient that we should give some particulars of the system here.

The principles upon which the system is founded may be very simply stated. A steam engine is but a form of heat engine, receiving its supply of heat from the boiler, and converting a greater or lesser portion of this heat into useful work. The more efficient the engine the greater will be the proportionate amount of heat thus transformed into work, and the less consequently will be the proportionate quantity carried off by the exhaust steam. We thus see that we measure the quantity of heat carried off by the waste steam of any engine during, say, a minute, and divide this quantity by the number of horse power developed by the engine during that minute, we get a certain number or constant which will enable the performance of that engine to be compared accurately with that of any other engine tested in a similar way. The more efficient the engine the lower, of course, its "constant" will be, and *vice versâ*.

We must next consider the means by which the quantity of heat carried off by the exhaust steam can be measured, and we may here remark that nothing could be more simple, and at the same time more accurate, than the apparatus which Messrs. Farey and B. Donkin, junior, have devised and employed for this purpose. In its simplest and most generally useful form, it consists merely of a wooden trough, or box, into which the whole of the water from the hot-well is led, this trough having several partitions across it, over and under which the water flows, so as to obtain at last a steady current, which, at one end of the trough, falls over a weir or a "tumbling bay." The height or head of water above the weir can be readily determined by the ordinary hook gauge, and this and the breadth of the weir being known, the quantity of water discharged in a given time can be readily and accurately calculated by the use of Beardmore's Tables, or equivalent formulæ. In practice it would be unnecessary to make these calculations more than once for any given apparatus, it being, of course, more convenient to mark on the gauge the discharge per minute corresponding to each given amount of head. To ascertain the temperature at which the condensing water enters the condenser and finally escapes, a good thermometer is, of course, all that is required. The number of degrees that the water is raised in temperature during its passage through the condenser, and the number of pounds of water thus heated during a given time, being known, we can, by merely multiplying these two quantities together, determine the number of pound-degrees of heat or thermal units carried off from the engine during that time by the exhaust steam. Dividing this number of pound-degrees by the number of horse power developed by the engine during the trial, we get the "constant" already mentioned.

All, then, that is necessary to test an engine on Messrs. Farey and Donkin's system is a wooden box with a tumbling bay, a good thermometer, and indicators for determining the power developed. It is by no means necessary that the trial should be a lengthened one, for it will be found that as long as a constant pressure of steam is maintained, and the engine is employed to do an uniform amount of work, the amount of heat carried off by the condensing water will also remain constant from hour to hour, and there is, therefore, no reason why the experiment should be extended for an inconvenient time. This is a very important point in favor of the system of testing of which we are speaking, as in all mills or factories an engine can be kept doing tolerably uniform work for a couple of hours or so without inconvenience, whereas if the trial had to be extended over a lengthened period (as would be essential if the quantity of water evaporated by the boilers and the amount of coal consumed were obtained in the ordinary way) much inconvenience and expense would be in most cases incurred.

We must now speak of another important point connected with this system of testing engines. Mr. Farey and Mr. B. Donkin, junior, have found, from experiments, that the "constant" of any given engine does not vary to any practical extent with moderate variations of power; and thus when the "constant" has once been obtained, the power developed at any given time by an engine fitted with the apparatus we have described can be ascertained very closely without the use of the indicator. For instance, let us suppose that it has been ascertained that the "constant" of any given engine is 480 or, in other words, that the exhaust steam of that engine carries off 480 pound-degrees of heat per minute for every indicated horse power. Then if, on observing the apparatus, it was found that 14,400 units of heat were passing away per minute, the engine would then be developing $\frac{14400}{480} = 30$ horse power, or if 16,800 units were being given off per minute, $\frac{16800}{480} = 35$ horse power would be developed, and so on. We thus see that the apparatus affords a very ready means of estimating the power requisite to drive various machines, shafting, etc., and we are inclined to believe that if it was generally applied to these purposes some curious revelations would be the result.

In cases where it is desired to maintain a continuous registration of the work done by an engine, Messrs. Farey and Donkin employ the simple arrangement of photographic apparatus described and illustrated in the letter from Mr. Farey to which we have already referred. According to this plan, two rays of light from a gas burner—the one passing through a hole in a screen carried by a float, and the other through a break in the mercurial column of a thermometer—are, after traversing lenses, made to fall upon a sheet of sensitized paper carried by a slowly revolving drum, which derives its motion from the engine. Each ray of course traces a line upon the sensitized paper, and by the distance of these lines above or below a fixed datum line traced by a third ray of light, the quantity and temperature of the water passing over the weir at any given time are registered. Applied in this way, the apparatus is calculated to do good service to large millowners and waterworks companies who desire to obtain a continuous record of the performances of their engines.

Hitherto we have spoken of this system of testing as applied to stationary condensing engines only; but it is also applicable to high-pressure engines, and, under certain circumstances, to marine engines. In the case of high-pressure engines, the exhaust steam would have to be turned into a tank of water and condensed, and the water thus heated could then be treated like that from the hot well of a condensing engine. In the case of marine engines, the vessel containing the engines to be tested would have to be lashed alongside a wharf, and the engines being got up to their intended working speed, the water from the hot well would have to be conducted into a box fixed to the wharf, and measured in the way already described. Of course in actual trials at sea some other method of measuring the water discharged from the hot well would have to be devised; but this being done, the system of testing would be as applicable at sea as on shore, as the rise of temperature of the condensing water could of course be readily ascertained.

We have spoken, at some length, of the system of comparing the performances of steam engines proposed by Mr. B. W. Farey and Mr. B. Donkin, jun., because we are convinced that it is one deserving the most attentive consideration of all employers of steam power. The experiments required for its application to any engine are of the most simple and inexpensive kind, and, when once understood, they may be carried out as easily as the taking of an ordinary indicator diagram. The system, moreover, gives for each engine a "constant," the favorableness or unfavorableness of which is entirely dependent on the performance of the engine itself, and which is not affected in any way by the efficiency or inefficiency of the boilers, by the quality of the coal used, or by the greater or less skill of the stoker. Once let such a standard of comparison as this become generally adopted, and we shall hear less of vague performances and more of really economical steam engine—a state of affairs earnestly to be desired.

Loads on Girders.—At a recent meeting of the Société des Ingénieurs Civils M. Leygue presented to the Société a detailed study on uniformly distributed loads, which, in their results, are equivalent to the loads caused by traffic on metal superstructures; that is to say, capable of producing in the sections submitted to the greatest strains caused by separate loads, the same maxima momenta of flexion.

M. Leygue first examined the conditions of variation, to the extent of the movement of the loads, of the maxima momenta produced by a series of forces, P, acting on a body resting freely on two level supports. In discussing the expression

$$\mu = A + B\,z,$$

which is the usual formula of flexion momenta for any section, he found that in the position, z, the most unfavorable of the system, one of the loads, P, was to be found in the section undergoing the greatest strain.

From this point the question of uniformly distributed loads becomes remarkably simplified.

If x be the abscissa of the maximum momentum under any specified load; π the uniformly distributed load producing the same effect as the separate loads, P; L the bearing of the girder; p the uniformly distributed load caused by the dead weight; F the resultant of distinct forces, P′; λ the distance of the load under consideration to the resultant, F; Σ P l the sum of the momenta in relation to the load under consideration, of the separate loads placed at certain distances on the abscissa x, we find

$$x = \frac{L}{2} - \lambda \frac{F}{2F + pL}$$

and

$$\pi = \frac{2F}{L}\left(1 - \frac{\lambda}{L - x}\right) - \frac{2\Sigma Pl}{(L - x)x}.$$

After having examined the conclusions to be deducted from these formulæ, M. Leygue presented to the Société the results of their application to underline and overline roadways. The calculations are arranged in the shape of tables and curves, in which the values π are considered as representing the performance of the bearings of the girders.

The general shape of the curves thus traced is hyperbolical with two rectangular asymptotes:

$$x = o \text{ and } y = \text{constant}.$$

In face of such results, and foreseeing what must take place in other companies from what has taken place in the Compagnie du Nord, M. Leygue was surprised that straight lines of 400 K., 4,000 K., and 5,000 K., should still be the standard indications in the administrative orders of the controller's office. It would seem to be more reasonable to permit the engineers to fix upon the loads for which they must calculate their works, and to simply place a certain limit to the molecular strains to which the metals may be submitted. In fact, the different pitches would allow the degree of stability of the works to be ascertained.

M. Leygue believed that the figures obtained by the formula (π) were also applicable to continuous girders supported by several bays. In fact, in a case of entire symmetry there will be found for a piece built in horizontally at both its extremities,

$$\pi = \frac{N(N+2)}{N+1} \cdot \frac{P}{L},$$

N representing the number of separate loads, P, distributed on the bay L; and this formula will be found *identical* in the hypothesis of free supports.

M. Leygue concluded by saying that he agreed with the expressed opinion of M. Bresse that the motion of the loads ought not to have a disturbing influence on the works. If certain observations seem to contradict this opinion, the reason probably is that the girders, by the relation of their component parts, were placed beyond the typical limits as regards which theory and practice are not in contradiction to each other. For this reason M. Leygue supported without any alteration the figures obtained by him, deduction being made for the speed of the rolling loads.

THE IRON AND STEEL INSTITUTE OF GREAT BRITAIN.—This body comprises upwards of 140 of the leading iron and steel masters, managers and engineers of the kingdom. Its objects as defined in the printed rules are, 1st, to afford the means of communication between members of the iron and steel trades upon matters bearing upon the respective manufactures, excluding all questions connected with wages and trade regulations; 2d, to arrange periodical meetings for the purpose of discussing practical and scientific subjects bearing upon the manufacture and working of iron and steel. The several similar institutions devoted more especially to civil engineering have proved of such signal advantage to all concerned, that great hopes are entertained of the usefulness of this new enterprise.

GOLD REGION IN SOUTH AFRICA.—"Peterman's Mittheilungen" contains a report on the gold region discovered by K. Mausch, in the south of Africa, between Limpopo and Zambesi. Quartz rock, very rich in gold, is found there extending over a length of many miles. Gold sand rich enough to be washed to advantage has not yet been discovered. Captain Black, who has acquired a considerable experience in gold mining in California, is managing the mining operations. He wishes to annex this gold district to the Cape Colony, and has given it the name of Victoria district. Gold mining companies have been organized in Natal, in the Transvaal Republic, and in the Cape Colony. Several European geologists have started for Africa. A scientific man is being sent there from England. Already, in October last, Germany sent Mr. Ed. Mohr, the experienced traveller, well acquainted with the south of Africa, and accompanied by O. Hübener, of the Freiberg Mining Academy. They have gone to Natal and the Transvaal Republic with the purpose of subjecting the gold district mentioned to a closer investigation.—*Oestr. Zeitschrift.*

New Method of Rifling and Working Heavy Guns.—The "Mechanics' Magazine" for May 14, 1869, illustrates in detail the scheme referred to, as designed by Mr. C. Pemberton, of the Royal Navy. A rifled bar of say 6 in. diameter is screwed into the bottom of the chamber and occupies the position in the bore that a piston-rod would occupy in a cylinder. The projectile is bored out and grooved to fit over this rifled bar, while the exterior of the projectile and the bore of the gun are smooth. The object is to avoid the weakening of the gun by the loss of metal and the sharp angles of grooves in the bore, and by the bursting strain caused by the rotation of the projectile. It appears to us, however, that the rifled bar would sag at the muzzle to such an extent as to make loading difficult.

Mr. Pemberton also shows a novel arrangement of air cylinder for taking up the recoil, and also for running out the gun; also a method of elevating the gun platform by screws, which we think vastly inferior to hydraulic power.

BLAST FURNACE ECONOMY.

From "Engineering."

To those who desire to effect economy in the carrying out of any process or manufacturing operation there is no knowledge more valuable than a knowledge of all existing sources of waste. In some cases such knowledge is easy to obtain; but in the majority of instances it is more or less difficult, and in none more so than in those in which the matter to be economized is fuel. Let us take the steam engine for example. We know that a certain quantity of fuel if properly consumed will produce a certain number of units of heat, and that if this number is multiplied by 772 we get the number of foot-pounds of work which this heat is capable of developing if completely utilised. But we also know that even with the best boilers and engines now constructed the amount of work actually developed falls immensely short of this theoretical quantity; there are losses caused by imperfect combustion, by heat carried off from the boiler furnaces, by the waste gases, by radiation, by condensation, by wire-drawing, by leakage, and by numbers of other defects, which it is unnecessary to mention here. The losses due to some of these various causes are known with tolerable accuracy, but with regard to others there is little definite information available, and the consequence is that they are not guarded against as they should be. If we knew exactly how every unit of heat developed in a boiler furnace is expended, who can doubt but that some substantial improvement in construction would be the result.

As with steam engines so with blast furnaces, respecting which we intend more especially to speak on the present occasion. That much has been done during the past few years—and particularly in the Cleveland district—to reduce the consumption of fuel in blast furnaces per ton of iron produced is undeniable; but it is equally undeniable that there is still margin for improvement, and it appears to us that one of the first steps to be made towards effecting that improvement is to ascertain with the greatest practicable exactness the losses amounting from each existing source of waste. These losses once known, they may be considered separately, and means taken to avoid them.

At the meeting of the Institution of Mechanical Engineers, held on the 28th of January last, during the discussion which took place on Mr. Cochrane's paper on the utilisation of waste gases from blast furnaces,* attention was especially directed to the differences which exist between the quantities of fuel actually consumed in blast furnaces per ton of iron produced, and the amounts which would be theoretically required; and the subject is altogether one of such importance as to deserve especial consideration. And here we may remark that it is quite impossible in the present state of our metallurgical knowledge to say precisely how much fuel is absolutely wasted in any given blast furnace. The quantities of fuel, ore, and fluxes introduced in any given time, and their analyses, may be accurately known to us; but our information concerning the quantities of heat rendered latent in destroying certain chemical combinations, the heat absorbed is liquefying the slag and iron itself; the specific heat of the liquid slag and iron, and other matters, is far from being so reliable as we could wish, and, consequently, as we have said, a thoroughly accurate estimate of the fuel required in any

* See Van Nostrand's Magazine, No. 2, p. 140.

given instance cannot, at present, be given. Notwithstanding this, however, we have sufficient data at our disposal to show that the amount of fuel actually used is greater than it should be, and it may be interesting if we consider this matter more closely. For this purpose it will be convenient if we take, as an example, a furnace worked with certain definite charges of ore and fuel, and show how the proportions between those charges agree with those which would be theoretically required.

Let us, for instance, consider a furnace, in which the charges consist of 26 cwt. of coke, 50 cwt. of ironstone, and 10 cwt. of limestone, per ton of iron run; the ironstone containing 40 per cent. of iron in the state of peroxide. We have chosen these proportions because they will enable us to readily compare our calculations with those of Mr. I. Lowthian Bell and Mr. Siemens given in the course of the discussion to which we have already referred; and which were founded on similar data. In the first place the coke used in the Cleveland district contains from 5 to 10 per cent. of ash and moisture, and if we assume that our particular sample contains $7\frac{1}{2}$ per cent. of these matters, we shall have to make a deduction of $1\frac{1}{2}$ cwt. from the quantity available as fuel. A further deduction of about 1 cwt. will have to be made for the carbon which combines with the iron, leaving finally $23\frac{1}{2}$ cwt. of carbon to be accounted for.

Peroxide of iron (Fe_2O_3) consists of 56 parts by weight of iron combined with 24 of oxygen, and the 50 cwt. of ironstone charged per ton of iron made contain, therefore, 20 cwt. of iron, 8.57 cwt. of oxygen, and 21.43 cwt. of other materials, principally silica. The decomposition of the peroxide is effected by its oxygen being taken up by the carbonic oxide gas produced by the imperfect combustion of the coke, this carbonic oxide being thus converted into carbonic acid. The amount of carbonic oxide required to decompose the given quantity of peroxide of iron is readily calculated. Carbonic oxide consisting of 6 parts by weight of carbon combined with 8 parts of oxygen, and carbonic acid consisting of 6 parts of carbon and 16 of oxygen, it follows that to take up the 8.57 cwt. of oxygen from the peroxide of iron 15 cwt. of carbonic oxide (composed of 6.43 cwts. of carbon and 8.57 cwt. of oxygen) will be necessary. This disposes of 6.43 cwt. out of the $23\frac{1}{2}$ cwt. of carbon. But in converting the oxygen of the peroxide from the solid to the gaseous form there is a great absorption of heat, and to supply this heat a consumption of fuel has to take place. It appears from the researches of Ebelmen and Schinz that the quantity of heat rendered latent during the decomposition of the peroxide of iron amounts to 718 units for each pound of oxide decomposed, and as in our example the quantity of peroxide is 28.57 cwt., the heat absorbed would be $28.57 \times 112 \times 718 = 229{,}748{,}512$ units. We must next consider the quantity of fuel required to supply this amount of heat.

If the whole of the carbon consumed in a blast furnace was converted into carbonic acid, each pound of it would develop about 14,000 units of heat; but, as a fact, it appears probable that, as estimated by Mr. Siemens, not more than one-fifth is thus converted, the remaining four-fifths assuming the form of carbonic oxide. As carbon, when burnt into carbonic oxide, only produces about 4,000 units of heat, we thus have as the average quantity of heat produced by each pound of carbon consumed in the furnace $(\frac{1}{5} \times 14{,}000) + (\frac{4}{5} \times 4{,}000) = 6{,}000$ units; and this we believe is a fair estimate. From these data we get $\frac{229{,}748{,}512}{6{,}000 \times 112} = 3.418$, or, say, 3.42 cwt. as the quantity of fuel required to supply the heat rendered latent during the decomposition of the peroxide of iron. We have next to consider the amount of heat rendered latent during the decomposition of the limestone; and, according to the experiments of Schinz, this amounts to 355 units for each pound of carbonate of lime decomposed. In our case, therefore, the quantity will be $10 \times 112 \times 355 = 397{,}600$ units corresponding to the consumption of $\frac{397{,}600}{6{,}000 \times 112} = 0.591$, or, say, 0.6 cwt. of fuel.

At the time that the iron and slag are discharged from a blast furnace they have a temperature which may be fairly assumed as about 2,400° higher than that of the materials at the time of charging; and we have now to consider the amount of heat necessary to liquefy them and give them this high temperature. The amount of heat rendered latent during the liquefaction of a pound of cast iron has been given by Clement as 233 units, and by Schinz as varying in different samples from 250 to 315 units. If we assume 250 units as the amount in the present case, we shall have $250 \times 20 \times 112 = 560{,}000$ units as the amount rendered latent during the liquefaction of the ton of iron. Again, the specific heat of cast iron in the solid state is 0.13, and in the liquid state about 0.16; and we shall, therefore, have $20 \times 112 \times 0.13 \times 2{,}000 = 582{,}400$ units of heat absorbed in raising the ton of iron to the melting point, and $20 \times 112 \times 0.16 \times 400 = 143{,}360$ units imparted to it after it is melted. Adding these quantities together, we get $560{,}000 + 582{,}400 + 143{,}360 = 1{,}285{,}760$ units; thus corresponding to the consumption of $\frac{1{,}285{,}760}{6{,}000 \times 112} = 1.91$ cwt. of fuel.

As to the quantity of heat rendered latent during the liquefaction of the slag, some little uncertainty exists, and it, moreover, no doubt varies in slags of different compositions. The researches of various continental experimenters, however, tend to show that 110 units per pound of slag melted may be taken as a fair estimate in ordinary cases. With the charges mentioned in our example, the quantity of slag produced would be about $29\frac{1}{2}$ or 30 cwt. per ton of iron made, and taking the latter quantity, we shall have $30 \times 112 \times 110 = 369{,}600$ units. The specific heat of slag, like that of iron, varies according to whether the material is in the solid or liquid form; but we may, without any serious error, assume it as being 0.2 throughout. The quantity of heat required to raise the temperature of the materials forming the slag about 2,400°, will thus be $2{,}400 \times 30 \times 112 \times 0.2 = 1{,}612{,}800$ units; and adding to this the 369,600 units absorbed during liquefaction, we get 1,982,400 units as to the total heat imparted to the slag, this corresponding to the consumption of $\frac{1{,}982{,}400}{6{,}000 \times 112} = 2.94$, or, say, 3 cwt. of fuel.

Summarizing the results above obtained, we get the following statement of the manner in which the 26 cwt. of fuel is disposed of:

	cwt.
Ashes and moisture in fuel	1.5
Carbonization of the melted iron	1.0
Carbon for combining with oxygen in ore	6.43
Fuel for melting iron	1.91
" " slag	3.0
" to supply heat rendered latent during decomposition of ironstone	3.42
" ditto during decomposition of linestone,	0.6
	17.86
Not accounted for above	8.14
Total	26.0

In the above summary we have taken no account of the heat carried off by the waste gases escaping at the mouth of the furnace, for we quite agree with Mr. Siemens in considering that this amount is more than balanced by the heat introduced into the furnace by the hot blast, supposing the latter to be heated to, say, 1,000°. A simple calculation will prove this. We have shown that of the 26 cwt. of coke, $23\frac{1}{2}$ cwt. would be actually consumed as fuel (for the amount which unites with the oxygen of the ore is really consumed), and of this quantity we have assumed one-fifth or 4.7 cwt. to be converted into carbonic acid, and the remainder, or 18.8 cwt., into carbonic oxide. The 4.7 cwt. converted into carbonic acid, would require $\frac{4.7 \times 16}{6} = 12.63$ cwt. of oxygen for their conversion, whilst the remaining 18.8 cwt. would combine with $\frac{18.8 \times 8}{6} = 25.06$ cwt. of oxygen in forming carbonic oxide. The total quantity of oxygen required for chemical combination alone would thus be $12.63 + 25.06 = 37.69$ cwt., and of this quantity 8.57 cwt. would be supplied by the iron ore, leaving 29.12, or, say, 29 cwt. to be provided by the blast. Taking the air as being composed of 22 per cent., by weight, of oxygen, 77 per cent. of nitrogen, and 1 per cent. of moisture, carbonic acid, &c., we have $\frac{29 \times 100}{22} = 131.7$, or, say, 132 cwt. of blast as the amount necessary to furnish the above supply of oxygen. The specific heat of air being 0.238, this quantity of blast if heated 1,000°, above the ordinary atmospheric temperature, will thus introduce into the furnace $1{,}000 \times 0.238 \times 132 \times 112 = 3{,}518{,}592$ units of heat.

On the other hand, the gases escaping from the mouth of the furnace consist of 4.4 cwt. of carbonic acid derived from the limestone, 8.57 cwt. of oxygen from the peroxide of iron, 132 cwt. of oxygen, nitrogen, &c., from the blast, and 23.5 cwt. of carbon, combined with the oxygen of the air and that from the peroxide of iron, in the form of carbonic acid and carbonic oxide. The total weight of the gases will thus be $4.4 + 8.57 + 132 + 22.5 = 168.47$, or, say, $168\frac{1}{2}$ cwt. Taking the specific heat of these mixed gases to be 0.24, and their temperature to be 600°, we shall thus have $169.5 \times 112 \times 0.24 \times 600 = 2{,}717{,}568$ units of heat carried off by them, this quantity being $3{,}518{,}592 - 2{,}717{,}568 = 801{,}024$ units less than is introduced by the blast. To some extent this over-plus would no doubt be reduced by the heat carried off by radiation from the pipes by the water circulating through the tuyeres, &c., but we think there can be little doubt that the heat introduced by the hot blast will fully compensate for that carried off by the waste gases.

It may be interesting if we compare our calculations as to the disposal of the fuel above given with the estimates given by Mr. I. Lowthian Bell and Mr. Siemens on the occasion of the discussion to which we have already referred. Mr. Bell's estimate was as follows:

	cwt.
Carbonization of the melted iron	1.0
Melting the iron, and keeping it melted on the hearth...........................	2.7
Ditto as regards the cinder	4.5
Heat carried off by the escaping gases	6.36
Heat rendered latent, including the 6.43 cwt. of carbon combining with the oxygen in the ore, say, altogether	9.00
Total	23.56

It will be noticed that in the above estimate, although Mr. Bell allows 6.36 cwt. as the equivalent of fuel carried off by the waste gases, he makes no allowance for the heat introduced by the blast. Assuming, as we have done, that these two quantities balance each other, and deducting from Mr. Bell's estimate the 6.36 cwt. just mentioned, we get, as a remainder, 17.2 cwt., a quantity closely agreeing with that shown by our own calculations. Mr. Siemens' estimate, which also agrees closely with our own, was as follows:

	cwt.	
Melting the iron....................	1.60	
Melting the cinder..................	4.13	
Heat rendered latent by reduction of ore,	3.19	
Carbon for combining with oxygen in ore and for carbonizing pig metal...	7.43	
		16.35
Ashes and water in coke, 10 per cent......		1.63
Calcining the limestone, &c., 10 per cent...		1.63
Total quantity of coke required.........		19.61

Of the 8.14 cwt. of coke per ton of iron, given in our own estimate as unaccounted for by the useful work done, a portion is no doubt expended in supplying the heat lost by radiation from the furnace, but we have no reliable data which will enable us to estimate what the amount of this loss will be. There is, however, little cause for supposing that it is sufficient to account for the heat generated by the combustion of about one-third of the total quantity of fuel, and there must therefore be some other sources of waste not sufficiently recognized, but which it is desirable should be sought after and, if possible, avoided. The demand upon our space will not permit us to say more on this subject here; but we intend to return to it on an early occasion.

THE MARTIN STEEL PROCESS.

Condensed and translated from a paper published by CONSTANTIN PEIPERS, Messrs. Martin's representative in Prussia.

Among the great number of new processes of steel manufacture invented within the last decade, the Martin process has been practically the most successful, and may perhaps in its further development stand side by side in importance with the Bessemer process. Though not attracting attention by any new or peculiarly original idea, it has rapidly come into extensive use by the great practical value it has for certain branches of the iron and steel manufacture.

It was on the 4th of April, 1864, when Mr. Martin, in his establishment at Sireuil, near Angoulême, first succeeded in making cast steel on the hearth of a regenerative furnace. The process was patented in France on the 10th of August in the same year. To-day, five years after this first successful trial, the process is worked in many places in France, and has been introduced into almost all the other industrial countries. The larger establishments accept and fill considerable orders for rails and tyres of Martin steel. Martin, himself, has manufactured gun-barrels regularly and without interruption since 1865. The furnace he uses for this purpose is producing one and a half millions of pounds of steel per year. Thus the process may be considered as a decided practical success. Also the technical journals and the highest metallurgical authorities have expressed their belief in the great future of this process.

The idea on which the Martin process is based is not new. Heath took a patent on it as early as 1839.* Numerous experiments have been made by others in the same direction, but without decisive success. Though Martin is not, therefore, the original inventor of the process called by his name, he has the great and undoubted merit of having found out, by numerous and costly experiments, the right proportions in the construction of the furnace and gas-producer, the most suit-

* Heath's patent of 1845 (see Van Nostrand's Mag., No. 6, p. 547) more nearly describes it.—ED.

able materials for the process, and the best manner of manipulating the same. Martin has given to the industrial world not a mere idea, but a complete method of manufacture, developed in its details, and perfected at a considerable experience.*

The general principle in this process is well known, and can be mentioned here in but a few words. A certain quantity of pig iron is melted on the concave hearth of a reverberatory furnace, together with some slag to cover the iron and to protect it from the direct influence of the air and the gases. Small portions of wrought iron are thrown successively into this iron bath, which operation is continued until a test taken from the furnace shows that the whole mass of iron possesses the softness and other properties of wrought iron. This melted soft iron is finally reconverted into steel by the addition of a well proportioned quantity of pig iron. The heat necessary for these operations is partly furnished by a regenerator connected with the reverberatory furnace. The wrought iron to be added may consist of hot puddle-balls just obtained from a neighboring puddling furnace; or wrought iron scraps may be used, being previously heated in a separate furnace, or by the waste heat of a heating furnace. The product of the process is tapped and run into molds, or cast into any required shape.

We intend to show, by the following remarks, what relative position the Martin process will occupy to the other modes of making cast steel now in use; how its results and products compare with those of the crucible and the Bessemer process; and how the new process, in remedying some of the disadvantages of both the above, fills a gap between them, and can be made useful to both.

It is hardly necessary to mention that the Martin process is a much cheaper method of making cast steel than the usual crucible process. It compares in cheapness, under favorable circumstances, even with the Bessemer process, with which it has in a few instances come into actual competition. Though mostly used as yet for the production of larger masses of steel, the Martin process is capable of producing also the finer and harder kinds of steel for tools and cutting instruments, though not of a very superior quality.

The best crucible steel is made in Westphalia, and partly also in Austria, by melting wrought iron together with cast iron. The same thing is done in the Martin furnace, which is in fact a large crucible, the metal being protected by a layer of melted slag. As, however, this process, when carried out in the crucible, requires but nine per cent of pig iron, the Martin process on the other hand using from 30 to 50 per cent, the products of the latter are liable to be somewhat less pure and of a lower quality than those of the crucible process, when worked with similar raw materials. But this can be remedied to a considerable extent by the use of chemicals, which Mr. Martin has used for this purpose with eminent success. Thus the Martin process will enable the cast steel manufacturers to produce their ordinary kinds of steel, which are the most in demand, at a very much lower cost than before. Another circumstance that will lead them to introduce the Martin process is this, that it offers a greater security for producing exactly the required degree of hardness than the crucible process. The latter uses a good many materials, the composition or qualities of which cannot always be exactly known, and it does not present any facility for testing the product before it is poured. In the Martin process, on the contrary, samples can be taken at any time from the steel or iron bath, and the composition of the baths can be easily altered, until it has obtained the desired qualities. The softest kinds of steel which it is so difficult to produce in crucibles, can be made in the Martin furnace with the same degree of security as the harder kinds, avoiding at the same time all the losses and irregularities often caused by the cracking and breaking of crucibles. It is therefore to be expected that the cast steel manufacturers will, for the greater part of their production, replace the crucible melting by the Martin process.

When compared to the pneumatic process, Martin's method may be said to furnish products equal in quality to the best, and superior to the ordinary makes of Bessemer steel, supposing similar raw materials to be used. This is owing, in the first place, to the above mentioned facility of controling the operations in a Martin furnace. The samples taken from time to time show the condition of the metal at any moment, and indicate exactly the point when the metal resembles wrought iron in its qualities, and when it has to be recarburized by a certain

* If Martin added enough to a process that had been abandoned to make it practicable, the patent for his invention is of course valid.—Ed.

weight of pig iron. After being recarburized the metal is kept in the furnace three-quarters of an hour to effect an even distribution of the carbon, thus insuring a perfectly uniform product. During this time the metal has ample time to complete the boil, to discharge all the gases generated in its interior by the previous reactions, and to settle down, forming a quiet homogeneous bath. After this it pours without bubbling, and produces ingots free from cavities or flaws. A sample taken a short time before pouring gives a perfect assurance in regard to its qualities. The tapping of the metal can be done in a larger or smaller stream, as required, thus allowing of its being poured into large molds or used for small castings, for which it is well adapted.

The fitness of a pig iron for the steel manufacture depends principally on the percentage of phosphorus it contains. As puddling purifies pig iron from phosphorus to a considerable extent in converting it into wrought iron, the Martin process, in using this purified wrought iron must also, from this reason, produce a better quality of steel from the same pig iron than the pneumatic process, by which a purification of this kind is not effected. This makes it possible that the Martin process may be worked with success in districts which produce a pig iron not sufficiently pure to make a good Bessemer steel, and from which the Bessemer process is consequently excluded. The plant required by the latter is, besides, much more expensive.

These considerations may be apt to induce Bessemer works, in whose interest it is to monopolize the production of the larger steel castings, to erect Martin furnaces for the purpose of making such castings of a better quality and more perfect soundness. But the Martin process is, besides, in another respect, of great value to Bessemer works, by its being eminently adapted to use up all their scraps, spillings and cuttings in the most advantageous manner that can be imagined.

The greater the progress and the extension of the manufacture of Bessemer rails and Bessemer tyres, the greater importance will the Martin process acquire, because it is adapted and necessary to work the old materials up again.

The Martin process cannot directly make a good steel from inferior pig iron. The pig iron it uses as such must be pure. But it can use to about equal advantage gray iron, spiegeleisen or white iron. Spiegeleisen, which plays such an important part in all the branches of steel manufacture, is also in the Martin process of a very high value. The results obtained with it, when used for the first bath in the Martin charge, were astonishing, the products combining a great natural hardness and solidity, with a high degree of toughness.

A Martin furnace can be worked together with puddling furnaces to great advantage, in which case a separate heating furnace can be dispensed with. The iron in the puddling furnace can, immediately after the boil, be taken into the Martin bath. This way of operating presents an excellent opportunity for the use of chemicals to purify and improve the products. For the pasty condition of the puddled iron, before being balled, makes it well adapted to be mixed with all kinds of chemical re-agents, which afterwards come in very intimate contact with the steel bath when the iron is thrown into it. Martin has made extensive experiments in this direction with remarkable success, especially in working inferior brands of pig iron. This process offers, in general, greater facilities for the use of chemicals than any other method of making steel, and is therefore highly capable of being improved and perfected by new inventions, which quality still more insures its future importance.

S.

RAILWAY DISASTERS—THE CAUSE.

Taking the verdict of the Coroner's jury in the late Long Island Railroad disaster as a text—a broken rail—"The Engineer" observes that such casualties in America are usually attributed to bad Welch rails, admits that much very bad iron has been sent us thence, and concludes, first, that it is "criminal" for American managers to buy iron that they know to be unsafe, and, 2d, that American rails are "ill used." This authority further says:

The exceptionally evil influences to which track is subjected in America may be classed under two heads; defects in the method of laying, and defects in the rolling stock. And here we may add that bad rolling stock causes quite as many accidents in the States as bad track.

As regards defects in the method of laying, it will suffice to state that, with exception of a few first-class lines on which accidents rarely occur, ballasting is nearly unknown. The consequence is a continually recurring irregular subsidence of the line, which renders it impossible that the rails can be equally supported at intervals throughout their length. In many cases, it is certain that double the proper distance practically intervenes between chair and chair, or sleeper and sleeper.* We need not stop to point out how severe a strain this throws on the rails. Furthermore, fishing is almost unknown, and rails are laid so badly, and keyed into the chairs after so slovenly a fashion † that they are exposed to a great deal of unnecessary pounding and hammering, sufficient under the circumstances to deteriorate any rails. If the substructure of American roads were better we should have fewer complaints regarding the bad quality of superstructure, that is, of the rails.

We have said that defective rolling-stock contributes to the destruction of rails in America, and we may repeat that it is quite as fruitful a source of disaster as the bad quality of rails. We constantly read in the American papers of fearful catastrophes due to the bursting of track. In the great majority of cases rails in the States are broken laterally, not vertically. Now it is claimed for the American bogie car that it, beyond all other machines, runs lightly. How is it, then, that track is so often burst? How is it that derailment is so common an occurrence in the States? We are always told that the fault is in the track, yet it has been proved over and over again that the track was good and sound, and that no ordinary violence must have been exerted to break it. All this while, too, no one has questioned the merits of the American car, with its bogie at each end; yet in this system of constructing rolling-stock there is reason to believe that the seat of much of the mischief lies. The Willow Tree accident supplies us with a case in point. After carefully perusing the evidence, we are led to the conclusion that the verdict we have recorded above is wrong; and one juror, Mr. Pearsall, after the rendition of the verdict, read the following statement as his positive belief in the matter:

"As one of the jurors sworn to inquire into all the facts and circumstances attending the deaths of William C. Rushmore, &c., I do find that the said persons came to their deaths from an accident to the car in which they were passengers, the car being thrown from the track, and from all the testimony in the case I am unable to arrive at the cause of the accident."

And he and other jurors added that they could not find anything peculiarly defective in the road, or likely to lead to the accident. There appears, indeed, to be no doubt whatever that the car which left the track got off first, ran for more than a hundred yards on the sleepers, and then broke a rail. Under such circumstances, it is obviously wrong to say that the bad quality of the rail had anything to do with the catastrophe.

The fact is, that bogies, as often fitted to American railway carriages—we beg pardon, "cars"—are very liable to get off the track. It is not unusual to make the wheel base of each bogie shorter than the distance between the rails. The consequence is, that the bogie runs with a sinuous movement, alternately jostling right and left. The cast-iron wheels are not always properly matched in diameter, and thus a constant tendency may exist for one side of the bogie to outrun the other. The cars are not coupled up tight in the train as with us, and they therefore cannot steady the wandering bogie. No one part of the train is a check on the rest, and therefore the chances of derailment are greatly multiplied. We need hardly stop to point out how severely the "wobbling" of a pair of short bogies stuck at each end of a tremendously long carriage, itself oscillating, must try the lateral strength of any track. Yankee engineers are disposed to laugh at our four-wheeled carriages, and to call us behind the age. We fancy that they would find it worth while just to try some of our rolling stock for a while. They have something to learn yet at the other side of the Atlantic from English engineers.

In conclusion, we may state that a letter on the Willow Tree accident, written by a Mr. Wood, has recently appeared in the "New York Times," which bears American testimony to the cogency of not a few of our arguments, as will be seen by the following extracts:

"As a resident landed proprietor along the line, permit me to write a few words with regard to it. The true solution of the matter is that the driver was going at unusual speed, and the last car oscillated from the track, striking and rebounding from the sleepers as it was dragged along, until it loosened a rail which jumped up and had its end caught in the truck-work of the car, which, still being urged on, bent and broke the rail in five places!

"*The true remedy for such mishaps is proper coup-*

* This is a very unusual defect in American track. Indeed, sleepers are often laid too close for proper tamping.—Ed.

† That is to say, not keyed into the chairs at all, the chair being, in most cases, a mere resting for the rail ends.—Ed.

lers, such as the English have, or better still, Miller's automatic coupling, used by the Erie and other great companies. Horrible as was the loss of life, it is well it was no worse under the circumstances; *but until more effective means of retaining the cars on the track when running at high speed be adopted, such will periodically occur*, though I believe the risk was and is aggravated on the Long Island Railroad by bad spiking, inferior iron, deficient ties, and a scamping of the work generally."

"The Engineer" is obviously not aware that the spread truck is usually employed, rather than the short truck, the defect of which it correctly points out. The merits of a properly constructed truck, as compared with a wheel-base the entire length of a car, are evident on mechanical principles, and besides this, they have been proved on the Canadian lines where the two systems have been used side by side. But the dangers arising from unmatched wheels, and especially from the want of the close, tight coupling of car to car, are very great, and should be more seriously and widely considered by our railway managers.

IRON FOUNDING.

"CASTING IN OR ON" TO THE SAME OR TO OTHER METALS—CONSTRUCTION OF FRAMES AND RAILINGS.

From "The Practical Mechanic's Journal."

When we say other metals, we practically mean cast iron, wrought iron, or steel, for no other metals occurring on the large scale in the arts have fusing temperatures such as admit of the processes about to be referred to being applied to them. Occasionally, though rarely, a few substances, not metallic, may be perhaps usefully treated, by the methods of "casting in or on"—for example, grit-stone or blocks of emery might be run round with cast iron so as to unite these into large grinding plates or cylindric surfaces and the like; but these are out of our way just now.

Whenever liquid cast iron, of whatever kind, is brought into contact with a comparatively cold surface of good conducting material, it is, as we have already seen, more or less "chilled;" its texture is altered, its hardness increased with its absolute cohesion, but its toughness diminished. This occurs more or less whenever a piece of wrought iron, or of steel, or of cast iron, cold or but moderately heated, is laid into a sand or loam mould, and the liquid iron which fills the mould comes into contact with it. Conversely, the wrought iron or the steel (and even less completely, and with somewhat different conditions), the cast iron with which the liquid cast iron has been brought into contact, and with which it has to cool slowly, and at the same rate, have their molecular status changed also. The wrought iron loses in ultimate cohesion and likewise in toughness, and new crystalline arrangements are formed within its mass, which, on the whole, deteriorate it as a structural material. Changes of like character are produced in steel, but not to the same extent, and tend rather to the enlargement of its constituent crystals than to materially injure it as a structural substance.

Theory alone would thus appear to place its ban upon any such operation as "casting in or on," and in some cases the verdict of mere theory would be approved as true, in its application to practice. Yet there are very many cases occurring in the every-day work of the iron-founder and mechanical engineer, in which the convenience and the economy of this method of uniting the metals are so great, and the changes induced upon both so unimportant, that theory is wisely overlooked or overridden in practice. Before alluding to some of these, let us take a glance at some of the cases in which theory *ought* to be our guide here, and in which the neglect of it is nearly certain to bring the practician to grief. This will be the case whenever it is important that the full and undiminished strength and toughness of both metals, the wrought iron and the cast iron, should be preserved.

The "crucial instance" of a case in which this is indispensable may be said to be found in the construction of artillery, machines in which every particle of the constituent material is simultaneously strained in three directions at right angles to each other, and by force suddenly or impulsively applied, and always so great as to bear a large ratio to the ultimate or crippling strain of the metal. Here, then, of all others, is the case in which "casting in" should have been avoided. Yet the method of making cannon by casting bronze or cast iron round a wrought iron or steel interior tube has been again and again proposed and often tried. In the older days of iron metallurgy, when these subjects were less distinctly understood, and when want of good tools gave some strong inducements, on economic grounds this method was excusable. The very same proposition has been but recently revived, however, by Major Palliser; and it was not before a large gun was blown to pieces at, we believe, the first round, at

Woolwich, that the inventor, with infinite candor, publicly declared that thenceforth he abandoned his method (which was not his, in fact), and conceded his adhesion, when too late, to the indications of theory. We are not always called upon to provide for such strains as cannon are exposed to, but whenever the strains upon any machine or structure are severe, and especially when they are impulsive, we shall do well to avoid "casting in."

Yet cases continually occur in practice where, even upon a very large scale, this method of combining the metals by laying the wrought iron into the mould and casting the cast iron round it, may be practiced with advantage and safety.

Thus, for example, in some of the great iron latticed viaducts upon the Commentry and Gannat branch line of the great Orleans system of railways in France, Mr. Nordling, C. E., the engineer-in-chief, has adopted the suggestion made to him by M. Eiffel, the founder and contractor for the iron-work of La Sioule Viaduct, and has united the corner or gusset plates of wrought iron with the cylindrical columns or shafts of the iron piers (which are of vast altitude), by casting the former into the cast iron of the columns. The success of the process appears to be complete in this instance. Here the mass of cast iron in immediate contact with the wrought iron is relatively large. There is, therefore, no very serious deterioration produced in the cast iron, which is the metal the more obnoxious to injury of the two; and on the other hand, the margin of safety allowed in all parts of these structures, and more particularly in the mass of these gusset plates, admits of some deterioration in the wrought iron constituting them, without running any risk.

To pass to the other extreme in point of dimension, we see this method in continual use amongst the founders of ornamental castings, such as light balusters, balcony panels, &c., into the sand moulds for which are laid short pieces of iron rod or wire, which, when "cast into" the extremities of these castings, become the means by which they are united by screw nutting or by riveting with the hand-rails and other parts of the architectural structures into which they enter. Here, as both cast and wrought iron are small in scantling, and the subsequent strains are small, some loss of strength or toughness can be afforded in consideration of economy.

Our chief aim now is to point out how largely and advantageously this method may have its use extended, and to give some examples. Let us first, however, recur in some degree to theory, and in the way of correcting a very prevalent error amongst many who might be presumed to know better, as to what *can* be effected by this method of casting in. It has been supposed over and over again that additional strength and toughness may be conferred upon castings in iron, by including in their interior a wrought-iron skeleton, which the cast iron, when run around it, shall clothe with itself, as the flesh encloses the bones of an animal. Thus, to quote but one example, several years ago, in the early days of railways, the late Mr. George Forrester, of Vauxhall Foundry, Liverpool, patented a method for making improved cast-iron wheels for railway wagons, by riveting or welding together in a rough and cheap way, a sort of skeleton wrought-iron wheel. This was tinned or galvanized, and after having been warmed, was laid in the dry sand mould, and the cast-iron wheel was poured and formed around it.

Such wheels, proved admittedly to be no better than if simply of cast iron, probably were not nearly as good as a well-made American chilled rim cast-iron wheel, and probably were in reality rather worse than the same cast wheels would have been *minus* their wrought-iron bones. It may be accepted as a fact, that no real accession of strength can be thus attained in any casting, if the cast iron be good soft gray or mottled metal; inasmuch as the extension per ton per inch of such, is actually greater than that of wrought iron for the first ton or two, so up to that limit at least the whole strain will come upon the one material only, helped by the slight surface adhesion of the two. Both materials also are in a state of initial strain more or less, dependent upon their diverse coefficients of contraction and their differences of temperature at the instant of consolidation of the cast iron. If, again, the cast iron be rigid and harsh, white or chilled or light mottled iron, then the whole strain is one of the two; and so these wheels, if made hard enough to have a tolerably well-wearing rim or tread, might break all to pieces, and all that the wrought-iron skeleton inside could do would be more or less imperfectly to hold the fragments loosely together. A remarkable and not uninstructive example of this was seen in 1867 at Paris, at the Great Exhibition contest between the bank safes of Mr. Herring and Mr. Chatwood.

The former maker fills the space between the outer and inner wrought-iron or steel plates of his safes with a plate of intensely hard Franklinite iron, poured in while in fusion. This is so hard that it cannot be drilled by ordinary means, but it is also extremely brittle, more so, apparently, than any ordinary white or chilled iron. As an alleged remedy for this, the Franklinite was cast upon or around a sort of network of tough wrought-iron cylindrical rods of about $\frac{5}{16}$-inch diameter, and it was affirmed that these conferred upon their hard and brittle surroundings their own toughness. When, however, plates of this combined material were broken up, which a few blows from a heavy hand-hammer were enough to effect, they proved just as brittle as ever. The dislocated fragments, it is true, or some of them, hung together, though more or less separated, by means of the reticulation of tough wrought-iron wires, and whose toughness did not in this instance seem to have suffered much change; but the plate as a whole broke up readily as before, and admitted of fragments being beaten out of it.

In Mr. Kirkaldy's museum at his testing works, Southwark, is a heavy cylinder of cast iron of very fine quality, in the middle of which is seen a very heavy concentric cylindrical bar of rather rigid wrought iron, cast into it. The original proprietor of this notable compound bar, of whom we know nothing, it appears brought it to be tested, and requested that the proof should be only carried up to some few tons per square inch, the allegation being that the cylinder was of some secret and improved *cast iron*. Arrived at this limit, the extensions appeared so strange to the experienced eye of Mr. Kirkaldy, that he resolved to go on *à l'outrance*, and so broke or pulled the cylinder in two, when, to the disgrace of some "person or persons unknown," the big wrought-iron bar was discovered in the middle. It was *this* bar, in fact, that was bearing nearly all the strain for the first few tons, and the cast iron when broken showed itself no better than common. It was creditable to the experimenter to have thus detected a disgraceful attempt at a *quasi* scientific fraud, but, besides the moral, we may draw also the physical lesson which we have been otherwise inculcating, from the result.

We thus may take it for granted that no increase of resistance, of any industrial value, at least, can be secured by trying to combine cast iron and wrougt iron or steel, by casting in, or one within the other. The advantages of casting in are limited, in reality, to economy, rapidity of execution, and convenience. We shall see that incidentally, however, in the case of wrought-iron structures, such as iron railings, or, as our French readers will better understand, *grilles*, certain additional advantages are secured.

The two following examples will at once illustrate the methods of practically employing the "casting in or on" process, and point out two of the chief classes of manufactured objects to which the process may with most advantage be applied. We shall take, first, the patent secured some years ago by Mr. David Moline, for a method of producing window sashes or frames by combining wrought iron with cast iron. The "muntins" of these sashes are formed of rolled wrought-iron bars in any of the usual rabbated sections fitted to receive the glass. These are cut or shorn off into appropriate straight lengths, equal nearly to the straight (or curved) sides of the panes. An iron pattern moulds the entire sash in the sand; when it is withdrawn, these straight pieces of iron sash-bar are laid into their respective places in the sand mould so that their ends approximate, four such coming together at each intersecting point, if the sash have square or rectangular panes. A boss or *patera* is moulded at each such intersection, ornamented or not, but of sufficient size to embrace the four disconnected ends of the wrought-iron bars, and when cast in iron, to solder or unite these together into one. These bosses are then "poured," either simultaneously by the aid of a compound "runner," or one or more at a time; the sash is then complete, all the loose pieces of "muntin" being so united together. They are extremely strong, may be made very ornamental, and have immense advantages, both in manufacture and in use, over the older sashes wholly of cast iron, in casting which it was always extremely difficult to preserve a light and large "muntined" sash free from bending, distortion, or fracture of some of the "muntins" while cooling, and the whole affair, if large, was so fragile as to scarcely bear transport, and to offer no resistance to violence.

The older and wholly wrought-iron sashes, on the other hand, in which the "muntins" intersected, and were united by "halving" or riveting to each other, were neither neat nor cheap.

Excellent examples of these improved sashes may be seen in the windows of the Ludgate Hill Station buildings of the London, Chatham and Dover Railway Station, in the front of the new Covent Garden Theater, and in many other places in London.

Casting wrought-iron pieces together in this sort of way is plainly not confined to the production of sashes. In fact, it has been employed, with excellent effect, by Mr. Thomas Page, C. E., in the production of two or three different classes of wrought-iron trellis railing, or fence, at the Chelsea Suspension Bridge, London, and its use in this direction might be largely extended with advantage.

The other example to which we shall refer is that of the grand line of *grille* or railing which extends for about 1,600 feet in a straight line, and forms the northern side of Nassau street, in Dublin, separating that from the park of Trinity College. This was designed by and executed under the direction of the writer. It consists of a succession of cast-iron perforated pilasters, of ornamental open work and work in relief, with caps and bases, and sustained by two scroll struts at the rear, at intervals of about 50 feet. These are "cramped," *i. e.* run with an alloy of lead and zinc, into the granite continuous base. The spaces between these are filled up by the *grille*, consisting of a flat wrought-iron horizontal top and bottom bar, each in one length, of upright round bars of wrought iron, and of cast-iron ornaments cast on to the same, which here form structural parts of the work.

In the production of this large quantity of railing, not a single piece of wrought iron was ever heated or put into the smith's fire. The top and bottom bars were rolled to the right length, and punched cold—the top one with $1\frac{1}{4}$-inch holes, all to let the vertical bars pass through them; the bottom one with five successive holes of $\frac{7}{8}$ diameter, and then one of $1\frac{1}{4}$ diameter, alternately. The round bars were ordered in two different lengths, five-sixths shorter (about $7\frac{1}{2}$ ft.), and one-sixth of them longer. Every sixth vertical bar passes through both the top and bottom horizontal bars, and for nine inches into the granite base, into which it is zinco-leaded, the lower end of the vertical bar passing through a hollow cusp, or foot-block, upon the top of which the bottom bar rests. The shorter bars are riveted cold through and at the bottom side of the lower horizontal bar, and pass through the upper one.

All the vertical bars being prepared and straightened perfectly by hand, the one-sixth longer being mere round bars of the proper length, and the five-sixths shorter with the bottom and neck collars, were then laid into sand moulds, in batches of twelve in one "box;" and the bottom and top ornaments, being moulded from hollow iron patterns, made to fit the wrought-iron pattern bars, and to keep their proper places and relative distances by means of steady pins, were then "cast on" to them. The top ornaments and then the bottom ones of each batch of twelve bars were "poured" simultaneously, and the sand was at once stripped off; the bars being all separately taken out, and the thin "gates" knocked off, which was all the dressing these ornaments required, or, indeed, admitted of; for though cast from soft gray pig, they were, by reason of their small relative volume, quite chilled through. Very few broke in cooling; very few were bad castings—and these were broken off from the bar by a blow or two of a hammer, and again others cast on. The hollow or open (as to design) halbert heads which complete the railing at top, were cast in green sand, and cored to drop on loosely to the top ends of the vertical bars, and so admit of being zinco-leaded on to the same.

Now, to erect this railing, the vertical bars were put into position, with the bottom horizontal bar, all laid flat into a wooden framing made to keep them in position and to clamp them so, until the whole sheet was hoisted into place. All the bottom ends of the collared bars were then riveted to the bottom horizontal bar. The "cusps" being in place over the holes "jumped" into the granite base, the whole sheet and frame was hoisted up by two tackles, and the longer bars dropped through the "cusps" into the holes in the base, the ends of the horizontal bar being inserted into the mortices in the pilasters, in which they were held fast, though free to expand and contract within these. The top horizontal bar was then dropped over the tops of the vertical round bars, until it rested upon the uppermost part of the top "cast-on" ornaments. The halbert heads were then dropped over the projecting tops of the vertical bars; the vertical bars, which were in the holes in the stone base, were zinco-leaded into same; the halberd heads were likewise so secured to the tops of the vertical bars, and then that length of railing was complete. A scroll rear strut corresponding with those of the pilasters was secured at the middle of each length, so that there are thus struts at every five-and-twenty feet, or thereabouts. If we have succeeded in making clear to the reader the processes followed, he will have recognized how small was the amount of workmanship expended in the production and erection of this railing. In reality it did not, upon the wrought-iron portion, amount to more than about 40s. per ton of the material.

The entire economy here was due to the application of the method of "casting on," for that alone permitted of all the other structural details being carried out.

One great advantage resulting from this method of construction is the possibility of dispensing with "leading on" the cast-iron ornaments as commonly practiced. So put on, every lead collar is an electro-negative galvanic element, increasing the tendency of the iron to rust, and causing the corrosion to be local and locally powerful. With many designs it would be practicable to dispense with the use of "cramping" or leading altogether. With that we have described this might have been done, at a little greater expense.

The writer, however, had proved experimentally that an alloy of zinc and of lead may be formed, whose galvanic relations to iron are much more nearly those of zinc itself to iron, than those of lead to that metal, and in fact such as not to cause any fear from its local increase of corrosion on the iron of railing. This alloy he adopted in place of lead, for what he has called the zinco-leading or "cramping" together, and the result has justified his experimental previsions, for after twenty-six years, and not more than four coats of dark green paint during the time, there are no signs of local corrosion whatever. Zinc itself would be best of all as a "cramping" metal, but it runs too thick and drossy to form a close or safe junction.

In some ornamental railing recently erected at Westminster, the uprights are secured without leading to the granite, by iron studs and screws and by Portland cement. This is, however, a bad plan; one may say "out of the frying-pan into the fire," for the bond of the thin plate of Portland cement is certain to be broken by the expansion and contraction of the metal, and then water will find its way in by capillarity, rust will form between, this will, as usual, expand in volume as compared with that of the metal from which it has been produced; and the railing will be lifted up or the base claws broken by it, or by the expansion of water frozen between the joints which it shall have entered.

The points upon which we have here been treating are wholly those of the practical ironfounder, and of the founder in one of his humblest capacities, namely, as the servant of the architect and builder. It is to be hoped that enough has been put before the reader interested in the founder's art, however, to impress upon his mind the advantages he may occasionally derive from the method of "casting on," and to indicate the cases in which and why it should be shunned, and also some of those in which it may be employed with a value and profit proportionate to the skill devoted to its special adaptation.

HISTORY OF DECARBURIZING IRON.

No. V.

MALLEABLE IRON AND STEEL SCRAP AND CAST IRON MIXED AND PUDDLED—ALSO ALLOYING OTHER METALS WITH IRON.

STIRLING, JOHN DAVIE MORRIES.—1848. October 12. No. 12,288.

"Improvements in the manufacture of iron and metallic compounds." The patentee, after referring to his letters patent of June 29, 1846 (see No. 11,262), describes his improvements in the manufacture of malleable iron and alloys of iron and other metals. 1st, in making malleable iron, he adds malleable iron scrap in proportion of from $\frac{1}{20}$ to $\frac{1}{5}$, or even $\frac{1}{4}$ by weight to white pig iron in the pig bed, or otherwise, and the mixture is then boiled and puddled so as to thoroughly incorporate the whole together. Another mode of mixing, which is preferred, is to melt the malleable and cast iron in a suitable furnace, and then run the liquid mixture into the puddling furnace; the expense of refining iron is by these processes avoided. If good qualities of cast iron be employed, larger proportions of malleable iron should be used. Refined iron may, if required, be also combined with malleable iron scrap. Steel scrap also improves the quality of the iron. To produce an alloy of malleable iron less fibrous and harder than the common iron, block tin or groin tin may be added in proportion of from $\frac{1}{200}$ to $\frac{1}{100}$ by weight to any of the above mixtures; bismuth, antimony, and arsenic may be similarly used, and also zinc and copper, which produces a hardening effect, and manganese, which gives a steely character to the iron. An alloy of zinc and iron is produced by introducing zinc into the cupola furnace when the charge has been lately run out; the zinc combines with the iron left adhering to the sides of the furnace, and forms a mixture which should contain from 4 to 5 per cent of iron; if it be found to contain less more iron should be added. The specification also describes a method of making an alloy resembling gold from zinc, iron, copper, and manganese, which is called British gold; also an alloy of copper and manganese; also an alloy of zinc, iron, and copper, and nickel, and manganese resembling silver.

[Printed, 5d. See "Repertory of Arts," vol. 16 (enlarged series), p 42; "Artizan," vol. 7, p. 231; "Patent Journal," vol. 7, p. 12; "Mechanics' Magazine," vol. 50, p. 381.]

ORE AND SCORIA MOULDED INTO BRICKS FOR PUDDLING FURNACE LINING.

WILLIAMS, GEORGE.—1849. January 13. No. 12,416.

"Improvements in preparing puddling furnaces used in the manufacture of iron." Iron ore and scoria are ground to powder and mixed with water, so as to form a kind of paste. This is moulded into bricks or slabs or other suitable shapes, dried and baked, and used as a lining for the sides and bottoms of furnaces.

[Printed, 6d. See "London Journal" (Newton's), vol. 35 (conjoined series), p. 19; "Mechanics' Magazine," vol. 51, p. 66; "Patent Journal," vol. 7, p. 173.]

PUDDLING FURNACE WITH TWO CHAMBERS; AIR AND STEAM JETS IN PUDDLING.

PLANT, REUBEN.—1849. July 18. No. 12,706.

"Improvements in making bar or wrought iron." The object of the invention is to regulate the heat during the process of puddling iron. A puddling furnace is described having two chambers, a puddling and a preparatory chamber, with a damper between them. Hot or cold blasts of air and jets of steam are used, as described, for regulating the heat in the chambers respectively.

[Printed, 9d. See "London Journal" (Newton's) vol. 36 (conjoined series), p. 173; "Patent Journal," vol. 8, p. 212; "Mechanics' Magazine," vol. 52, p. 61.]

AIR HEATED BY THE BRIDGES AND SIDES OF A FURNACE AND FORCED INTO ITS CLOSED ASHPIT.

PRIDEAUX, THOMAS SYMES.—1849. August 30. No. 12,750.

"Improvements in puddling and other furnaces."

Firstly, a puddling furnace is described having a closed ashpit to which air is supplied under pressure. The air is conducted through pipes or passages regulated by cocks or valves under the bottom of the puddling furnace and through the bridges, so that it becomes heated, and the sides and bottom of the furnace and bridges are cooled. The heated air is thus forced into the closed ashpit, and introduced into the furnace, or it may be introduced through openings in the sides of the furnace.

Secondly, a smelting furnace is described, having a fireplace in the front, and behind that a kind of crucible, and behind that a smelting chamber into which the ore is introduced through a hopper. The smelting chamber communicates with a chimney. Air is forced through suitable passages formed in the brickwork of the lower part of the furnace, and is supplied in a heated state, and under pressure, to a closed ashpit, and thence introduced into the furnace.

[Printed, 10d See "Repertory of Arts," vol. 16 (enlarged series), p. 25; "Mechanics' Magazine," vol. 52, p. 194; "Patent Journal," vol. 8, p. 270.]

PUDDLED STEEL—ALSO, DECARBURIZING CAST IRON BY HEATING IT ENVELOPED IN CLAY, AND BY PASSING AIR OVER IT WHILE HEATED.

RIEPE, EWALD.—1850. Jan. 29. No. 12,950.

"Improvements in the manufacture of steel." These consist, firstly, in a peculiar manner of working the puddling furnace. A charge of about 280 lbs. of pig iron is introduced and raised to a red heat, when the fluid begins to melt the damper is partially closed to lower and regulate the heat. Twelve or sixteen shovelsfull of slag or cinder iron are then added, and the whole melted down. The mass is then puddled with a little black oxyde of manganese, common salt, and dry clay ground together. After the mixture has been acted on for some minutes the damper is fully opened, and 40 lbs. of pig iron (or if the ore be sparry iron ore, 20 lbs.) are added, and melted with the charge at a cherry-red heat; as to this part of the process minute directions are given.

Secondly, pig or alloys of pig and wrought iron are cast into thin bars $\frac{1}{4}$ to $\frac{3}{4}$ inch in thickness, these are enveloped carefully in best plastic clay and heated in a furnace for from one to three days, until they are converted into steel. A suitable furnace is described for this process.

Thirdly, the iron bars cast as above described are placed in a cylinder made of fireproof stones so as to allow a stream of atmospheric air to pass through and touch freely all the bars. The cylinder is bricked up at the end, as described, and the bars heated until they are converted into steel.

[Printed, 7d. See "Repertory of Arts," vol. 16 (enlarged series), p. 222; "London Journal" (Newton's), vol 37 (conjoined series), p. 175; "Mechanics' Magazine," vol. 53, p. 98.]

MAKING STEEL BY MELTING ORE, STEEL AND WROUGHT IRON TOGETHER.

ONIONS, WILLIAM.—1851. February 7. No. 13,496.

"Improvements in the manufacture of steel." These consist in melting certain matters together and running the product into castings directly, and then annealing them. Two parts by weight of hematite ore with four parts by weight of common steel, and 94 parts of iron made from Cumberland or other like ores, are placed in a crucible and melted. The metal, instead of being run into ingots, is run at once into moulds of the required shapes. The castings are then annealed, and are so rendered malleable, when they may be treated in like manner to articles made of ordinary steel. The annealing is carried on in like manner to that resorted to in annealing articles made of cast iron from Cumberland and similar ores, whereby they are rendered malleable. Articles like bars, about an inch square, should be raised to a red heat in 24 hours, and maintained at that heat for about 120 hours, and then gradually cooled. Cast-steel articles so made may be cut or dressed or partially formed and tempered like articles made of ordinary steel.

[Printed, 3d. See "Repertory of Arts," vol. 18 (enlarged series), p. 331; "London Journal" (Newton's), vol. 39 conjoined series), p. 344; "Mechanics' Magazine," vol. 55, p. 136; "Patent Journal," vol. 11, p. 231.]

NOTE.—*The effect of the small percentage of ore must be to slightly decarburize the iron and steel.*

PIG IRON BOILED WITH ORE AND CARBONACEOUS MATTER MIXED, COOLED IN A SPONGE, GROUND, ASSORTED, REHEATED AND BALLED.

HAZLEHURST, ISAAC.—1851. June 3. No. 13,655.

"Improvements in the manufacture of iron." These relate to the puddling process. The iron is puddled in the furnace with a mixture of iron ore and carbonaceous matter, as ground coal, coke, charcoal, or sawdust. When the iron is puddled the damper is to be lowered until the metal begins to thicken, "it is then boiled and kept very hot until it becomes very thin or liquid." The draught is then "checked until the metal is brought into a state" ready "to ball." It is then drawn out in convenient size, but "without being balled, and placed in a closed barrow, or other receptacle" made to exclude external air, and left to cool. It will then be in a spongy or honeycomb state, and is to be crushed or ground by stampers or rollers; the bad or imperfectly worked iron must be picked out, and as much good iron as will make a bloom is put in a furnace and balled at a low heat, and worked under the hammer or squeezer in the usual way. The iron so made does not require cutting and piling, and is suitable for spades, edge tools, boiler plates, wire, &c. If required to take a polish, the crushed or ground iron should be scoured. The ground iron is also used "for sinking in the charcoal fires, for making iron for conversion into steel," instead of charcoal pig or best scrap iron.

[Printed, 3d. See "London Journal" (Newton's), vol. 30 (conjoined series), p. 282; "Mechanics' Magazine," vol. 55, p. 495; "Patent Journal," vol 12, p. 121.]

FRANKLINITE USED IN THE PUDDLING FURNACE.

JONES, S. T.—1851. September 16. No. 8,357. (U. S.)

CLAIM.—The application of Franklinite to the improvement of iron in the processes of reduction from its ores, and in the finery or puddling of crude or pig iron, according to the methods as above described.

CHROMIUM—ALSO SALT, BARYTA, LIME AND SODA—USED IN THE PUDDLING FURNACE.

STIRLING, JOHN DAVIE MORRIES.—1851. December 22. No. 13,877.

"Certain alloys and combination of metals." This invention is an improvement on that patented by the inventor on January 31, 1851. See No. 13,486. It relates to coating metals, such as iron, copper, tin, &c., with metals and metallic compounds, as tin, copper, zinc, lead, gold, platinum, &c., and their alloys.

Also in improving the quality of iron by adding chromium, by preference, in the condition of chrome iron, or chromate of iron, in proportion of from $\frac{1}{400}$ to $\frac{1}{800}$ of each puddling charge; or it may be added at an earlier stage than the puddling process. When the iron is particularly cold-short or red-short a chloride is added, and common salt, at the rate of $1\frac{1}{2}$ to 3 lbs. to each charge. The chromate is to be added when the iron is nearly or quite melted, and the softer iron takes more than the harder class.

Also, instead of chromium, baryta, or its salts, by preference, the carbonate may be added to iron, 1 lb. of carbonate to each charge in the puddling furnace.

Also carbonate of lime and muriate of soda, in equal proportions, may be advantageously added to the iron; from 2 to 3 lbs. of the mixture being added to the puddling charge.

NOTE.—*The patent also specifies using lead and chlorides in the blast furnace.*

PUDDLING—THE FIRST PERIOD WITHOUT STIRRING. THE PRODUCT MELTED WITH EXCESS OF CARBON AND REMELTED WITH IRON TO DILUTE THE CARBON.

COLLINS, WM. WHITTAKER.—1852. March 24. No. 14,033.

"Improvements in the manufacture of steel." A communication.

A charge of about 4 cwt. of grey pig iron is "melted in the puddling furnace in the ordinary way, with a large quantity of silicate of iron or other metallic oxyde." The first period of the boiling process is continued without "stirring or raking the metal," as is ordinarily done. The melted mass is thus left quietly exposed to great heat, "by which means the impurities, less the carbon, are burned." This process is continued for from 15 to 30 minutes, according to the nature of the iron. The iron will then begin to rise up, and must be then worked vigorously "under the action of the highest degree of heat," to make it fit, as soon as possible, to be balled up for the hammer or squeezer or rolls.

The product will be pure "close-grained iron," which "either in the state of milled bars, balled iron, or finished bars, will unite with facility with various proportions of carbon." They are, therefore, without previous cementation, "melted in crucibles, with the application of carbonizing substances, by which means cast steel is produced," of which the degree of hardness "may be regulated by the application of carbonizing substances in greater or less quantity."

"A superior quality of cast steel adapted for tools, chisels, &c., is obtained by melting the said bars with a comparatively large proportion of carbonizing substances." The product is a highly carbonized brittle cast steel. "This is to be remelted with fresh parcels of the said iron bars."

[Printed, 3d. See "London Journal" (Newton's), vol. 41 (enlarged series), p. 317; "Mechanics' Magazine," vol. 57, p 279.]

DECARBURIZING CAST IRON BY HEATING WITH OXYDE OF ZINC OR LEAD, TO MAKE BARS WITHOUT PUDDLING.

BEAUVALLET, JEAN ERNEST.—1852. June 12. No. 14,167.

"Improvements in the manufacture of iron and steel. A communication. These consist in heating cast iron "in contact with a metallic oxyde (or it may be "a carbonate which will act by reason of its oxyde)," and afterwards extending it by hammering or rolling, without the necessity of puddling it. Directions are given as to the way in which the iron is to be cast in bars or sheets, so that the impurities and bubbles may form their ends, and be cut off with the rough ends of the sheets or bars.

For the decarbonization of cast iron protoxyde of zinc and calamine are preferred, but oxyde of lead may be used. A table of proportions is given. The zinc, if any remain, is to be driven off by heat. When malleable iron is to be made, much of the decarbonizing substances must be employed; when steel is to be made less will be required, but the steel should be cemented with charcoal in the ordinary way, to expel the zinc and equalize carbonization.

[Printed, 4d. See "Repertory of Arts," vol. 20 (enlarged series), p. 363; "Mechanics' Magazine," vol. 57, p. 497.]

HARBOR DEFENSE—FLOATING GUN-CARRIAGES.*

BY SIR WM. G. ARMSTRONG.

From the London "Times."

Sir Wm. G. Armstrong calls attention to the value of small vessels (like the "Staunch," designed by Mr. Rendel), for defending seaports against the sudden inroads of hostile ironclads in time of war. The importance of protecting commercial harbors from this kind of attack is a subject which deserves more attention than it appears to receive. The intrusion of an invulnerable war-ship into the port of Liverpool, for example, is alarming to contemplate. Masses of merchant ships closely packed in docks, and large stacks of warehouses containing merchandise worth millions, are objects upon which the powerful shells of modern artillery would produce terrible effect. To prevent the ships of an enemy from approaching our shores would require our fleet to be ubiquitous, and if hostile ironclads cannot be kept at a distance, there is nothing at present to stop them from entering our ports. The experience of the late American war shows that it is very difficult to intercept a steam war-ship on the open seas; and under present circumstances it is certainly presumable that, whether we should happen to quarrel with the United States or with an European power, vessels would be fitted out on the other side of the Atlantic for inflicting every injury upon our property and commerce.

Let us consider, then, what is necessary for the defense of our seaports. We may presume that the kind of vessel which would be used for making a dash at a harbor would be a steamer large enough to unite speed and sea-going qualities with the protection of heavy armor. She would carry guns of great size, adapted alike for engaging and opposing ironclads and throwing enormous shells. She would be rendered secure against boarding, and be protected against small arms. Without heavy rifled guns no impression could be made upon such an enemy as this, and of such guns there are none in any one of our commercial harbors. Supposing, however, the guns to be forthcoming in time of need, we have still to consider how they can be most advantageously applied. We have, in fact, to choose between mounting them on fixed or floating platforms. If we plant them as fixtures, the batteries containing them must be at points where the channel can be commanded within easy range, and where a boom or other obstruction can be thrown across to detain the invader under fire. Without such detention, the time occupied in running past a battery is too short to admit of decisive results. The rapid motion and constantly varying distance of the vessel would make it difficult to hit her in a vital part, even if cool deliberation and judgment were used; but the difficulty would be enormously increased by the hurry and excitement that would prevail among the gunners during the brief passage of an enemy's ship. There is, however, this objection to booms and similar obstructions, that they cannot be so contrived as to be capable of stopping an enemy without at the same time interrupting commercial traffic. Nor is their efficacy as a barrier certain, since it is hard to say what steam an iron cannot break through. So that, altogether, the method of protecting harbors by batteries and booms is not very promising. If we now turn to the other alternative of using the guns afloat, we shall find that the difficulty vanishes. The vessels for carrying the guns need be nothing more than floating gun-carriages, like the little Staunch. This vessel, though a mere barge in point of size, carries a $12\frac{1}{2}$-ton gun, the movements of

* The idea of floating gun-carriages, as here referred to, though well carried out in England, is not of English origin. The "Naugatuck," built by the late E. A. Stevens, and fought in the late war, was merely a floating gun-carriage, the gun (100 pr.) being trained by turning the vessel by means of twin screws. See "Ordnance and Armor," p. 591—ED. *V. N. M.*

which are effected by steam-power, so that a very small screw suffices for working it. The boat is propelled by twin screws, which give her such a power of turning that she can change the direction of her large gun as easily and quickly as if it were mounted on a turn-table. She is incumbered with no armor, because her safety lies in her smallness, which renders her difficult to hit, and because armor is worse than useless when opposed to guns capable of piercing it. Finally, she is cheap. The cost of a couple of ironclad frigates would furnish a hundred Staunches.

Now, to revert to Liverpool as an example, let us see what would be the aspect of the case if half-a-dozen of these gunboats were at hand when an enemy's ship ran into the Mersey. She would there find herself surrounded by six little dots upon the water, carrying among them an armament probably even heavier than her own. They would be so small that she could not well hit them, while she would be so large that they could hardly miss her. She could not run them down, for they would be far too quick at turning, and a retreat under shallow water would always be open to them. If by a lucky shot the enemy were to sink or disable one of her assailants, it would be but one silenced out of six. She, on the other hand, would be equally liable to be sunk or disabled by a single shot, so that the chance of victory would be six to one against her, even if she were as difficult to hit as her adversaries. In short, six such gunboats would probably suffice to baffle the attack of several ironclads, and we might be very sure that no hostile attempt would be made to enter a harbor where it was known that these dangerous watchdogs were kept.

Nor is it merely their mobility within the area attacked that recommends these little vessels. The Staunch has proved herself an excellent sea boat both with her gun on deck and in the hold, into which it can be lowered at pleasure by her mechanism and again raised when required. Such vessels, therefore, could quickly be brought from different ports to any point attacked. Moreover, they would constitute excellent schools of gunnery for the naval reserve men, who might in them, at small cost, gain valuable experience in handling heavy guns. Indeed, I should not despair of a class of naval volunteers being established capable of managing such gunboats, and thus rendering every port self-protective. Again, if we are to contemplate the possibility of aggressive war on our part, these vessels will be quite capable of crossing a sea in company with suitable tenders, and would thus be available for foreign service in case of need, or they would prove valuable auxiliaries for the defense of our naval arsenals, if threatened with attack. When not in use they would be laid up on slips, almost free of cost for maintenance, and they could be lanuched, armed and manned at very short notice.

In offering these brief suggestions on the subject of harbor defense I do not wish to ignore the great value of torpedoes as aids in guarding the entrance of a port; but these implements cannot be looked upon as superseding the use of artillery for that purpose. Even with the best arranged system of torpedoes, it is not difficult to conceive a mode of attack by which the defenders might be deceived either into exploding them prematurely or upon comparatively valueless ships sent in for the purpose; and once exploded, a new system could not be laid down in the presence of the enemy. In fact, there is no knowing what expedients might not be resorted to for evading or neutralizing their effects. For my part, I am persuaded that nothing would prove so free from objection as small gunboats with big guns. But, whatever difference of opinion there may be as to the best mode of attaining the object, certain it is that at the present time we are prepared with nothing that would have the least chance of proving effectual.

In conclusion, I would observe that the preference I have expressed in favor of guns afloat over guns in fixed batteries has reference altogether to commercial harbors, and does not apply to great naval stations like Portsmouth or Plymouth, where much more powerful defenses are required, and where a combined system of fixed and floating batteries would probably be necessary.

NOTES ON RAILWAY CONSTRUCTION.

BY W. AIRY.

From "The Engineer."

It may fairly be said that in England there are scarcely two railways alike; the country is so diversified and irregular in its outline, and so varied in its soil and geological character, that there can scarcely fail to occur, in the course of the construction of a railway, difficulties peculiar to that railway. Such difficulties may not have been of such importance as to form the subject of a separate memoir, but they are, nevertheless, important to those who are engaged in such work, and if carefully recorded by the engineer in charge, they would form a most valuable mass of information, and from which a book on railway construction could be compiled far more trustworthy than any work compiled only from theory, or the limited experience of a single individual. For the publication and circulation of such notes there would seem to be no more proper or convenient channel than the columns of the best engineering papers of the day, in which they would be preserved for reference. In the following notes the writer does not profess to confine himself to what may be novel in the methods he adopted, but to record the methods themselves, and the experience gained in the application of them.

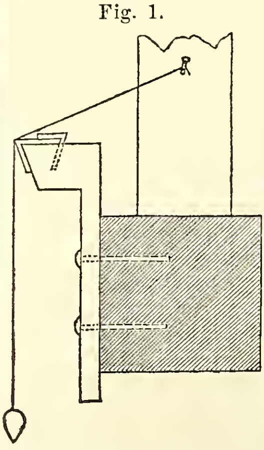
ON SETTING-OUT IN TUNNELS.

There is no ordinary field work so anxious or careful as that which occurs in the steering and setting out of a long tunnel. The chances of error in transferring lines and levels from the top to the bottom of a shaft are considerable, and the carrying on of them properly below ground is also liable to error, from the darkness and the shortness of the base from which to produce the line of the tunnel onwards. Now the accuracy needed in transferring the line of the tunnel from the top to the bottom is according to the number of the shafts; if the shafts are very close together—say, for instance, 100 or 200 yards apart, as they commonly are—the accuracy needed is not exceedingly great, but in proportion as the distance between the shafts increases, so also does the accuracy required, and when, as rarely happens, the shafts are as far apart as 700 yards, the accuracy needed is very great.

In the instance now recorded, a lofty range of hills, which was pierced by the tunnel, precluded the use of numerous shafts; the distance between two of the shafts was more than 700 yards, and in consequence of great difficulties, arising from the quantity of water encountered, the work was much hindered at one of these shafts; so that more than 600 out of the 712 yards between them were pierced from the other shaft, which was comparatively unincumbered with water, before the headings met. For the ranging of this length of 600 yards no method presented itself so practicable as the ordinary process of suspending two lines from the sill of the shaft in the line of the tunnel, and carrying on the line of the heading from the direction so obtained. But as the shaft was only 9 ft. in diameter, and the net distance obtainable between the two lines, so as to allow them to hang perfectly clear of obstructions of all kinds, was only 6 ft. 6 in., it was obvious that unusual care must be taken in the production of so long a line on so short a base. Had the tunnel been straight from end to end, it would have been safer and less troublesome, in this instance, to have ranged the line from the open end, where the heading emerged; but there happened to be a sharp curve at both ends of the tunnel, which would have rendered this method uncertain and indirect.

Now to arrange a line accurately below ground, by means of a pair of lines let down a shaft, it is necessary, first, that the lines should be accurately adjusted at the top; and, secondly, that the direction of the tunnel should be accurately produced from the direction indicated by the lines as suspended. In the instance in question the adjustment at the top of the shaft was managed thus: The center line of the tunnel being truly ranged above ground by the ordinary process, a station on the line was established and carefully marked at a few yards' distance from the shaft; a theodolite was placed over this station, and adjusted so as to range the true line of the tunnel. On each side of the shaft, and in the line of the tunnel, a board, of the shape shown in the figure, was firmly nailed to the sill of the shaft; this board was furnished with a movable nosing of iron, which was tightly clipped down upon the board by iron clips, so as to be firm and secure from shifting, yet capable of adjustment along the nose of the board by tapping lightly at the ends with a hammer. A small notch was filed on the edge of the nosing to receive the plumb-line. The nosing being roughly adjusted to the line of the tunnel, and the plumb-line passing over the notch and down the shaft, the observer at the

Fig. 1.



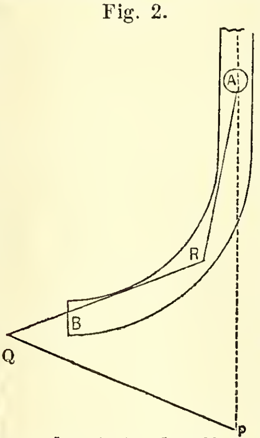
theodolite indicated the true position of the notch to an assistant at the board, by whom the iron nosing was gently tapped with a hammer till the notch and plumb-line were together brought into the true center line of the tunnel. The same was done at the other side of the shaft, and the adjustment at the top was then complete. In this way it is seen that a very high degree of accuracy was obtained, with great security and freedom from accidental shifting of the lines. The plumb-lines were of very strong and fine fish-line, and the plumb-bobs suspended in buckets of water at the bottom of the shaft in the usual manner.

For the production of the line of the tunnel below ground, the following plan was adopted: A stout deal table, on three legs strongly framed together, was firmly planted in in the line indicated by the plumb-lines, and at a distance of about eight yards from them; on this table was placed a theodolite, properly furnished with a lamp for illuminating the wires; this theodolite was placed roughly in line, and adjusted level by the foot-screws. The nearest plumb-line was then illuminated by two men with candles, and the theodolite was pointed so as to bisect that plumb-line, and was clamped fast. The two men then left the front plumb-line, and in like manner illuminated the back plumb-line. This line would appear in the telescope to one side or the other of the intersection of the wires, and the theodolite was shifted on the table to one side or the other, as was indicated by the observation. The whole operation was then repeated anew, and continued until, by successive approximations, the telescope was so truly adjusted to the line indicated by the plumb-lines, that after it had been directed so as to bisect the front plumb-line, the back plumb-line, on being illuminated, remained invisible from the obstruction of the former. Having thus obtained the true line of the tunnel, and carefully clamped the theodolite, the telescope was turned in a vertical plane, and candles were ranged by signal at such distances along the heading as were necessary, and permanent marks established at fixed places for reference.

It may not be uninteresting to know the degree of accuracy which may be insured by the above process. In order to eliminate all chance of accidental error, the work was done three times over from the beginning, at intervals of a month, and on each occasion a permanent nail was fixed in the line ranged at ten chains distance from the shaft. The three nails were driven side by side, and the distance between the two outside nails was $3\frac{1}{2}$ in., thus the limit of error at 30 chains' distance from the shaft would be less than 1 ft. The actual error, as was proved when the headings met, was less than 1 in.

As a check upon the above process, the following plan was used after the heading at the end near the shaft had been driven through to daylight. It is evident that the accuracy of this method depends much upon the number and position of the stations, which the curve renders necessary, as also on the size of the heading, etc.; but it may in some cases be found practicable and useful. Let A B be the heading, A the shaft, and B the open mouth of the heading. Let A P be the line of the straight portion of the tunnel as ranged on the ground, P a station on that line. Take a station at Q, near the mouth of the heading, from which P can be seen, and a station inside the heading at R, from which Q can be seen, and more stations if necessary, until A (a station vertically below the center of the shaft) can be seen; measure by theodolite all the angles A P Q—P Q R, etc. Then, since the fig. A P Q R—A is a closed figure, and all the angles are known except the last angle (in the figure it is P A R), this angle also can be determined. Therefore, planting the theodolite at A, pointing the telescope in the direction A R, and setting off the angle R A P, determined as above, the direction A P is obtained; and by turning the telescope in a vertical plane, the line of the tunnel, supposed in the direction of P A produced, may be ranged with considerable accuracy.

Fig. 2.



There is no great difficulty in setting out the levels of a tunnel. Leveling is such accurate work that an error at commencement does not seriously increase with the distance if moderate care be used. All that is necessary is to obtain pretty accurately the level of a bench mark at the bottom of the shaft; this may readily be done by tying two or more chains tightly together, the chains being first carefully measured, and suspending them from a nail in the sill of the shaft, the level of which is known; with these, and a level-staff to close in the measurement at the bottom, the level of a nail at the bottom may be ascertained to a quarter of an inch without difficulty. The levels may then be carried on by candle-light with great ease to the end of the heading in the usual way. The light of a candle, held near the object-glass of the telescope, though not so as to obstruct the view, is amply sufficient to illuminate the wires; and the staff, when lighted up, can easily be read at five or six chains distance, if the heading be not choked with smoke or otherwise obstructed.

ON THE MANAGEMENT OF CLAY SLOPES.

Very few railways exist which do not at some place or other pass through clay, either in the form of detached beds or pits, such as occur in all geological formations, or else as a recognized formation in itself; and there are no beds which give so much trouble in the construction and maintenance of railway cuttings, except perhaps the beds of running sand holding much water, which are comparatively rare. The varieties of clay beds are wonderful; in the experience of the writer there were found in the short distance of ten miles all kinds of clay, from black shaly clay, which would stand at a slope of 1 to 1 without slipping, to yellow greasy clay, which would barely stand at 3 to 1 (and which the slightest rain rendered very difficult to handle), and again to black rotten clay, which would not stand at 6 to 1, and indeed seemed unwilling to stand at any slope whatever. There seemed to be no principle of general application which ruled the nature of the clay, except that wherever water was present, the clay was worse to handle, and that clay on the sides of hills through which the drainage of the country had to percolate was worst of all. As a rule the clay of the earlier formations was firmer and better than that of the latter, and the black clay was better than the yellow; but the pitch of the ground and the position of the cutting would at any time affect the working of the clay very largely.

When, from the nature of the clay and the local circumstances of a cutting, it is apprehended that the slopes will not stand at the inclination originally intended, thero are various methods of proceeding which may be suitable for different cases. The chief of those which were tried in the case of the railway in question were as follows:

1. To get out the slopes to a flatter angle of inclination than was at first intended.

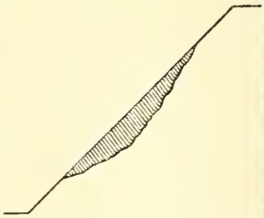
2. To get out the slopes with a curved batter, keeping the width across the cutting at the top the same, or nearly the same, as was originally intended.

3. To retain the foot of the slope by a low wall, and to flatten the remainder of the slope above the wall by taking stuff from the top of the slope and casting it down against the back of the wall.

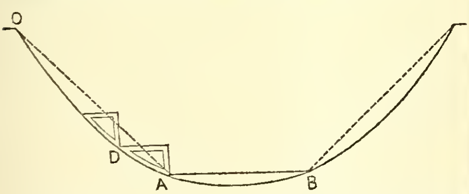
4. To drain the slopes, whether by bushes, rubble-drains, or pipes.

The first of these methods is the most wasteful of all; the labor required in getting out the slopes to a flatter angle is very great, and there is usually a necessity for purchasing additional land, which involves much expense and delay. Nevertheless, in exceedingly bad ground there is nothing else to be done, more especially if the ground be much charged with water, for then the slopes will not bear shaping. But this method will be much assisted by retaining the toe of the slope in some degree; a low wall of rubble-stone well hand-packed will keep a slope quiet at a comparatively steep angle of inclination, which would slip immediately and constantly without it, and give incessant trouble. The wall should be let into the ground to a depth of about 3 ft. below formation level, and if well laid and of good thickness, will save much money in maintenance; it should be of dry rubble-work, to give free passage to the water.

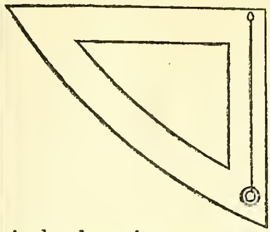
The second method is not commonly practiced, and is too much under-valued. It is rather more troublesome to get out slopes to a curved batter than to a straight one, and in consequence all gangers and workmen have a great objection to using this method; but it is the natural and stable form of the ground when laid to a slope, and the only correct form in which to leave it. In very good ground, which requires only a slope of $\frac{3}{4}$ to 1, or thereabouts, there is no great object in going to the trouble of making the slopes hollow; but as a general rule, a great saving might be effected by it, both in the first cost of the railway and in the subsequent maintenance. As regards the correctness of the above statement, it will readily occur to all who have had experience of railway slopes, that when a slip takes place in a straight slope, it rarely begins at the top of the slope; a wedge-shaped mass of stuff breaks out from the middle and lower parts of the slope, as in the annexed diagram, and slides down into the cutting; the top remains, sometimes overhanging, and, if not attended to, gradually crumbles away and falls down piecemeal.



Such an appearance suggests at once the proper shape to which a slope should be worked, and in one or two instances in the writer's experience the slopes were purposely and carefully worked to curved batters in the following way: The curve selected for the batter was the parabola. What the precise theoretical curve might be is not easy to ascertain, and the conditions of ground vary so exceedingly in different situations, that it would avail us little to know it for any precise case. It is something like a parabola, and as it was necessary to assume some curve or other, the parabola was selected, both as seeming suited to the case, and as being simple in its properties, more especially as regards its area, which is important as offering facilities for the calculation of the cubic contents of the earthwork. The principle on which the curve was applied will be seen from the diagram annexed.

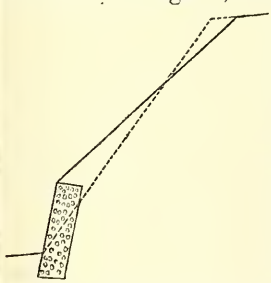


AB is the formation width of the cutting; A C the straight slope; A D C the parabolic slope; the constant of the parabola was so fixed that the two sides of the cutting, when completed, would, if produced underneath the formation, form the entire parabola; the object of this was that, as far as possible, the pressures of the two sides might balance each other without wedging up the formation between them, as sometimes occurs when the batters are straight. For the setting out of the slopes, two curved templates were made and applied as in the figure above. A draft was first traced



in the slope to the straight line A C; then the first, or lowest, of the templates was applied, and the draft deepened till the outside edge of the template was vertical; then the second template was applied, with its lowest angle at the point where the first template left off, and the slope in like manner dressed off till the outside edge of the second template was vertical. The slope being thus started true to curve, the rest of the draft could be completed with sufficient accuracy by eye, and the cutting got out between the drafts in the usual way. The above method is fairly simple and easy, and the cutting is far more secure than when the slopes are flat. This was curiously exemplified in one case where the slopes of a cutting had been dressed as above, except at two points where the batters were left straight from some accident; at both these points a slip took place in the following winter, while the rest of the cutting remained secure. As a general addition to the security of a cutting, this second method is the most correct, and involves the least expense.

The third method is very useful and convenient; the application will be seen from the annexed diagram, where the dotted lines



show the state of things as at first intended, and the full lines the amendment. The wall may be of any hard stuff, big and small together, except the face, which should be of large pieces, hand-packed. Chalk was found excellent for retaining the yellow clay, and the expense of such rough work is very insignificant. The great advantage of this method is that it involves very little, if any, removal of stuff in wagons, and the work can therefore be carried on without blocking the way. The wall should, if possible, be got in before the cutting has slipped much; if the slopes have slipped in, and the clay is much mixed with water, it is very difficult to keep the clay out of the wall, and to make good work.

With respect to the fourth method, so far as the writer's experience went, it is useless to attempt to save a cutting from slips by draining the slopes during construction. For the maintenance of completed railways it is, of course, necessary to allow free passage to the surface water; but for this purpose surface drains are sufficient, and the introduction of deep drains into clay slopes is in general most injurious; the deep drains do in fact, in most cases, lead the water into the body of the slopes, instead of keeping it out; the continuity of the ground is injured, and slips take place in consequence of the drains. Moreover, deep drains are very apt to get choked, especially when any slight motion is taking place in the cutting, and immediately a body of water collects, to the great injury of the slopes. The work of laying in deep drains is very costly, and in no one instance on the railway in question did it stop the progress of a slip for a single day; bushes, large rubble drains, and pipe drains were all employed, but without the least effect, and the slopes had either to be got out flatter, and the stuff removed in wagons, or retained by a rubble wall, according to the third method here given.

If different beds are met with, special methods must be used, as benching the slopes at places, which may sometimes be done to great advantage. The weak point of a cutting is the toe of the slope; it is usual to cut a grip on each side of the way to run off the water, and this grip often seriously undermines the slopes, and causes many slips. This may be to a great extent prevented by using pipes instead of open grips, and covering them over with loose stones, taking care also to provide gulley-holes to catch the dirt which drains into the pipes, and would otherwise choke them; but the best way of protecting the toe of the slope is to build a stout rubble wall, as suggested above in method No. 1. Without some such protection the slopes are in continual danger for long after they are made; they may stand the first winter, and even the second, without giving the least sign of a slip, and yet slip for nearly their whole length at the third winter, and give great annoyance. This, no doubt, is often due to the effect of weathering on the clay; but from whatever cause it arises, it at least shows that the work which is sufficient for temporary stability, does not always suffice for the permanent security of the cutting.

Experiments on Plate Heating by Liquid Fuel against Coal, made at Chatham Dockyard, May 26, 1869:

	Number of experiments.	Dimensions of furnace.	No. of grates.	Grate surface.	Description of plate.	Dimensions of plate.	State of furnace when put in.	Time of lighting or putting in plates.	Time of drawing plate.	Time employed in heating plate. h. min.	Combustible used.	Quantity of ditto.	State of plate when taken out.
Oil furnaces.	1	2.70 ft. × 5.0 ft. × 2.0 ft. high.	None	7 holes $\frac{1}{8}$ in. diam.	Armor.	7.3 ft. × 3.6 ft. × 6 in.	Cold furnace and cold plate	a. m. 8 30	a. m. 10 30	2 0	Creosote oil.	In heating the three plates, Nos. 1, 2 and 3, 67 gals., weighing 705 pounds were used.*	White hot; considered more than sufficient for bending; very equally heated.
	2	The same.	"	"	Armor.	9.4$\frac{1}{2}$ ft. × 3 ft. 3 in. × 6 in.	Hot from the preceding trial	10 55	p. m. 12 5	1 10	"		White hot; considered a very good bending heat.
	3	The same.	"	"	Keel plate	10 ft. 10 in. × 3.0 ft. × 1$\frac{1}{8}$ in.	"	p. m. 2 0	2 16	16	"		Very white; flattened when laid down by its own weight.
Coal furnaces.	4	21.0 ft. × 5.0 ft. × 2.6 ft. high.	2	16 ft.	Armor.	Same as in experiment No. 1	Cold furnace and cold plate	a. m. 9 0	12 50	4 50	Hartley main coal.	19 cwt.	About two-thirds of this plate were at an amealing heat; the part next the grate only was sufficiently hot for bending.
	5	The same.	2	"	Keel plate	Same as in experiment No. 3	Hot from the preceding trial	p. m. 1 50	2 51	1 0	"	3 cwt.	Two-thirds of the plate were nearly white hot, while the other part could not be flattened by hammering.
	6	17.0 ft. × 5.0 ft. × 2 ft. high.	3	19 ft.	Armor.	Same as in experiments Nos. 1 and 3.	Cold furnace and cold plate	a. m. 8 30	1 5	4 35	"	19 cwt.	Better heated than in experiment 4, but still unevenly heated, and for the greater part not sufficiently hot for bending.
	7	The same.	3	"	Armor.	Same as in experiment No. 4	Hot from the preceding trial	p. m. 1 25	4 15	2 50	"	12 cwt.	Altogether insufficient; an annealing heat only, and that very unequal.

* One cwt. coal was employed in heating generator from which the creosote vapor was supplied.

NEW BRIDGE OVER THE THAMES.

From a paper before the Civil and Mechanical Engineers' Society "On the bridge over the Thames carrying the West London Extension Railway." By Mr. LAWFORD, M. Inst. C. E.

This bridge consists of five segemental arches of wrought iron, each arch having a span of 144 ft. on the skew, with a rise of 16 ft. or 1-9th of the span. There are also, on the Middlesex side of the river, six, and on the Surrey side four, land arches of brickwork, each with a span of 40 ft. and a rise of 10 ft. The total length, therefore, of the structure is 1,270 ft. The abutments and piers of the five main openings are massive pieces of masonry, and are carried to a depth of 36 ft. below Trinity highwater mark, and 14 ft. below the bed of the deepest part of the river. The soffit of the arches at the crown is 22 ft. above Trinity high-water mark, in accordance with the requirements of the Admiralty. The level of the rails is 26 ft. above Trinity high-water mark. The width of the river between the two abutments is 776 ft. on the skew and 706 ft. on the square. The width of waterway afforded is 720 ft. The angle at which the bridge crosses the river is 75 deg. The greatest depth of water is 22 ft. below high-water, the average rise and fall of the tides at this place being about 13 ft. 6 in.

The piers were constructed in coffer dams, the inner row of piles being 5 ft. from the outer edge of the lowest course of masonry, and were driven to a depth of 15 ft. below the bed of the river; the outer row were 5 ft. from the inner row, and were driven to a depth of only 8 ft. from the same point, the space between the two rows of piles being filled with puddled clay. At the conclusion of the work the outer row of piles were drawn, but the inner row of piles were cut off level with the bed of the river. As the masonry of the piers proceeded, the space between them and the piles was filled with puddled clay, well trodden in to a height of 3 ft. above the bed of the river. Each pier stands on a bed of concrete 2 ft. thick, extending 3 ft. beyond the lowest course of footings. On the concrete is laid a course of York landings, 1 ft. thick, and projecting 1 ft. beyond the footings.

The foundations are carried up in a brickwork to within 2 ft. of the bed of the river, where there is a through course of stone 2 ft. thick. From this point to the springing of the arch the pier is faced with picked face ashlar of Bramley Fall stone. There is a second through course of stone half way between the bed of the river and the springing, and the upper, or last 7 ft. of the piers, including the springers, which are 3 ft. thick, are entirely solid stonework. The two abutments are built similarly to the piers, except that they have hollow chambers, filled with gravel to a height of 3 ft. above the springing of the arch; each abutment being just on the edge of the river required only half a coffer-dam for its construction. All stonework of both piers and abutments above springing height is tool dressed. The concrete used in this bridge was composed of five parts of gravel to one of blue lias lime, and the mortar of two measures of sharp sand to one of the same sort of lime.

Each of the river arches is composed of six wrought-iron ribs, arranged in pairs, 2 ft. 6 in. apart from center to center. The arch or voussoir of the four main or inside girders is formed of $\frac{3}{8}$-in. vertical plates, 39 in. deep at the springing and 24 in. deep at the crown, with double angle irons, each 4 in. by $3\frac{1}{2}$-in. by $\frac{1}{2}$ in., top and bottom, to which the flanges are attached by means of rivets. There is also a packing strip 8 in. by $\frac{1}{2}$ in. between the angle iron and the flanges. The flanges consist of two $\frac{5}{8}$ in. plates, 18 in. wide. The upper member of the inside ribs is a horizontal parallel girder, similarly constructed, but only 24 in. deep, throughout its entire length. The vertical web is $\frac{1}{4}$ in. plate from the pier to the point where the upper and lower member intersect, *i. e.*, 15 ft. from the center of the arch, and from this point both vertical webs are $\frac{3}{8}$ in. in thickness. The bottom flange of the horizontal girder consists of one plate $16\frac{1}{2}$ in. wide by $\frac{1}{2}$ in., two angle irons $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in., and a packing strip 8 in. by $\frac{1}{2}$ in. The upper flange is 15 in. wide, all other dimensions being the same as those of the lower flange; but the top plate is slightly curved inwards towards the rails. In the two outside ribs the voussoir is constructed as already described, but is 30 in. deep at the crown and 39 in. at the springing. It may be as well to mention here that in these two girders, on the outside faces of the arch, all the rivets, excepting those in the angle irons, are countersunk, no cover plate either being visible at the joints. The whole centre web presents, therefore, the appearance of one smooth unbroken plate. This center web is $\frac{3}{8}$ in. plate, the two flanges are single $\frac{1}{2}$ in. plates 16 in. wide, the angle irons $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in., and the packing pieces 8 in. by $\frac{1}{2}$ in. The upper member is constructed in the same manner as that of the inside rib, but it has throughout the whole span $\frac{1}{4}$ in. vertical plates, and is only 18 in. deep at the crown of the arch. The upper flange is 18 in. wide, and is parallel with the lower flange, which is only 15 in. wide. The angle irons and packing pieces are of the same dimensions as those already described for the inside top members. The total depth of the girders, both inside and outside at the center of the arch, is the same, viz., 48 in.

The sectional area of each of the four main girders is as follows:—In the arch at the springing, 80 square inches; in the upper member do., 43 square inches—total, 123 square inches; and at the center of the arch, where the upper and lower members are together, 105 square inches, the mean average being 114 square inches. These are the full sectional areas, including the rivets. The voussoir and the upper horizontal girder of the four main girders are connected together by a lattice spandrel, composed of H-iron, of three different sizes, viz., 7 in., 6 in., and 5 in. by $\frac{1}{2}$ in. A stiffening bar of flat iron, $\frac{3}{8}$ in. thick, is added to each side of the H-iron, connecting the lattice bars throughout at the angles of intersection. In the outside girders the lattice and stiffening bars are all made of double T-iron, riveted together, thus $\frac{\perp}{\mathrm{T}}$, and of the same dimensions as the H-iron. *i. e.*, 7 in. by $3\frac{1}{2}$ in., 6 in. by 3 in., and 5 in. by $2\frac{1}{2}$ in., all $\frac{1}{2}$ in. iron. Each pair of ribs is connected near the haunches by means of frames, composed of angle irons, cross-braced and riveted to the ribs, forming an open box girder. This principle is continued to the crown of the arch, where the voussoir and top girder unite in a double cell. Each pair of main girders are braced together at the haunches by means of trellis transverse girders 2 ft. 6 in. deep, carried up at equi-distant intervals to within 10 ft. of the center of the arch. There are seven of these in each half arch; they are composed of angle and bar iron, $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in. The top members of the main ribs are secured together by the cross girders, which carry the roadway; the are fixed over the whole length of the bridge, 4 ft. apart from center to center, and are composed of a middle web of iron, 10 in. deep and $\frac{1}{2}$ in. thick, the bottom of which is flanged with double angle iron, $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in., and the top by double channel iron, on the lower flange of which the buckle plate flooring rests. The cross girders rest on the lower flange of top main girder, and are secured in their places by iron knee-pieces, riveted through the center webs. The main or bearing girders are again cross-braced by diagonal rods, bolted to a center plate, and to brackets riveted on to each of the angles. There are three sets of these tie-rods in each half arch.

Upon the end of each arch or voussoir a plate of cast iron, 3 in. thick, is fixed, the back of which is planed quite true and even. These, again, fit into heavy cast-iron shoes (weighing 2 tons each), let into the stone skewbacks of the piers and abutments, and by means of wrought-iron wedges are finally adjusted in their seats. Contraction and expansion are provided for as follows:—Cast-iron standards are bolted to the stone-work of the piers and united by a cast-iron frame, secured with bolts and nuts. These standards have recesses to receive the ends of the horizontal girders, and secure them in position, at the same time allow for horizontal motion. A bed and bearing plate, planed perfectly parallel, are fixed under the ends of the horizontal girders, upon which they slide.

The railway is a double line of mixed gauge, and is carried over the bridge by means of longitudinal timbers with transons every 10 ft. Ash ballast is used all over the bridge. A cast-iron moulding is attached to the horizontal girder, throughout its whole length, and a cast-iron plinth is bolted on to the top of the same; an ornamental cast-iron parapet is fixed on the plinth, and the whole is surrounded by a wooden hand rail. In the experiments made for testing the quality of the iron, it bore a tensile strain of nearly 18 tons per square inch, without showing any signs of fracture.

The width of the bridge between the cast-iron parapets is 30 ft. in the clear. The total width of the piers from out to out above springing level is 35 ft. 6 in., and at that level, including the cut waters, 53 ft. 6 in. The total cost of the bridge was £104,000, or £82 per lineal foot, and £2 10s. per superficial foot. The materials used in its construction were 2,000 cubic yards of concrete, 11,100 cubic yards of brickwork in mortar, 130,000 cubic feet of stone, 2,160 tons of wrought iron, 366 tons of cast iron, 2 tons of lead, and 28,000 cubic feet of timber, exclusive of the piles. This bridge was the joint design of Messrs. Baker and Bertram, the chief engineers of the Great

Western and North-Western Railways. It was opened for public traffic on March 2, 1863, since which date some hundreds of trains have passed over it daily, and I am not aware that, up to the present time, any expense whatever—beyond the maintenance of the road—has been incurred, either in repairs or otherwise. The bridge was only 15 months under construction, *i. e.*, from the time the first stone was laid until a locomotive passed over the river. The bridge was very severely tested on January 7, 1863, by Captain Tyler. The narrow gauge load consisted of two locomotives and tenders, funnel to funnel, and two tank engines; total length of train 132 ft., total weight 176 tons. The broad gauge load consisted of two tank engines, in the same position as the narrow gauge engines, each drawing six loaded coal wagons; total length of train 276 ft., total load 292 tons; these two loads, collectively, being equal to about $2\frac{1}{3}$ tons per lineal foot. First, the narrow gauge load passed over No. 1 arch at speed, the deflection 5-100ths of a foot. Second, the broad gauge load passed at speed—same result. Third, the broad gauge load on one road and narrow gauge on the other, both passed together over No. 2 arch at speed. On going over No. 1 arch, No. 2 rose 3-100ths of a foot. On going over No. 2 it deflected nearly 10-100ths of a foot, rise and fall 13-100ths of a foot. Fourth, both loads were brought to rest on No. 2 arch, deflection 11-100ths of a foot. When the loads passed slowly over No. 3 arch, No. 2 rose 2-100ths of a foot, rise and fall 13-100ths of a foot. Both loads remained stationary for some time on this arch, but no further deflection took place, and, with the removal of the load, the girders rose simultaneously to their original height. Fifth, the same thing was done on No. 3 arch with a precisely similar result. Sixth, the same experiment was made on the fourth arch, and in exactly the same manner as the fourth experiment—rise of arch 2-100ths of a foot, deflection 10-100ths of a foot, rise and fall 12-100ths of a foot. Seventh, the same thing was done on the fifth arch; the rise was 2-100ths of a foot, deflection 8-100ths of a foot, rise and fall 10-100ths of a foot. The bridge was very steady throughout these experiments, and there was very little lateral vibration, even when both loads passed at the same time in the same direction, either slowly or at speed.

CEMENT FOR ROAD MAKING.

From the "Building News."

If there be one thing in ordinary life in which we seem to have made little improvement in late years, it is surely road making. Compared with the numberless improvements effected in all other directions, it may seem strange that we have learned so little wisdom in reference to this important public convenience. Our thoroughfares are, sewers and drains excepted, very much what they formerly were. The traffic has immensely increased; the wear and tear have proved proportionately great, while the difficulty of interfering with the traffic to execute repairs or renewals has grown more perplexing. Streets are constantly being pulled up, much to the inconvenience of the public, and most of all to shopkeepers; while newspaper complaints have become so customary that few persons heed them, and no one ventures to act upon them. We think the whole subject of road making deserves full and scientific inquiry, and he will be a public benefactor who can lead Englishmen* to improve their methods of laying down roads with greater facility, and of making them less perishable.

It is not because we think the use of Portland cement for road making will effect all we want that we direct attention to its employment for our public thoroughfares. By many it is at present regarded as little else than a novelty, and may, perhaps, be so considered for some time to come. A few years since Mr. Joseph Mitchell, until recently a general inspector of roads and bridges in the northern counties of Scotland, paid particular attention to the subject of macadamized roads. The cost of maintaining these roads, it is well known, is a considerable item in all local accounts. He made experiments which proved that a cubic yard of macadamized stone, when well pressed down in a box with a capacity of 27 cubic ft., contains 11 cubic ft. of vacuities; and that a roadway covered with 12 in. of metal, before it is consolidated into a smooth and useful surface, has a large portion of its stones crushed into small particles. He also discovered that more than one-third of its dimensions consisted of mud and sand. The result consequently has been that the stones in such a roadway, where the traffic is heavy and wet weather frequent, disintegrate to a very

* If the subject is unsettled in England, what is it in America?—Ed. *V. N. M.*

great extent; the greater the traffic, the greater the quantity of mud generated. Six or twelve months' traffic will play sad havoc in most of our public thoroughfares, as we all know; and not even the hardest stone can stand the heavy traffic of our great cities and towns. The ordinary mode of laying down streets accounts for much of this failure. We have before now denounced the loose methods which obtain throughout the country in reference to this matter. Nothing seems more absurd or primitive than to lay the granite in a bed of sand, beating it down a few inches, and then covering the interstices with sand that the first rainfall will speedily reduce to mud or wash away. And yet this is the ordinary process of constructing roadways, a process which necessarily leads to each stone being insulated, and, resting on a yielding surface, to give way very speedily. Mr. Mitchell found that in a street so constructed the ends of the causeway stones were worn down after twelve months' traffic from one-half to three-quarters of an inch. This, of course, arose from the fact of the percussion of the wheels of carts and carriages falling from the center of one stone on to the joint of the two adjoining, which sank from the pressure. "When a stone," he says, "has sunk bodily from one-half of an inch to an inch, or when a little hollow occurs in the pavement of the street, it will commonly be found that the adjoining stones are much worn, the hollow on the surface increasing the force and effect of the percussion of the wheels. The greater the hollow the greater is the tear and wear from the strokes of the wheels."

It was these and other facts which led Mr. Mitchell to consider the propriety of using Portland cement for roadways. Mr. Mitchell's plan is exceedingly simple, and its simplicity commends it to all minds. He first lays down a bed of cement concrete three inches deep, instead of providing a yielding surface. In cases where gravel is more easily procured and is cheap, it may be used instead of macadamized stone. The concrete soon gets firm, and of course excludes all moisture from below. He then places the paving-stones on this base, and, when brought to a perfect form, the joints are filled with cement grout. The paving-stones are five inches deep and three inches wide, a width of three inches being found to give a better hold to the horses' feet than the ordinary widths of 4 or 4½ inches. He holds that when properly consolidated such a surface is perfectly immovable to traffic and impervious to moisture. If, he adds, the causeway be well made, no irregularities on the surface should occur; when they do exist, it is attributable to defective workmanship.

This plan has been tried in three places with varied results, in the first case, at Inverness, in 1865; and at the end of two years, having been subjected to a heavy goods traffic, the road was perfectly sound, requiring no repairs, and presenting a marked contrast to the macadamized roadway adjoining it. The second attempt, in London, is an admitted failure. In this case the traffic was much more severe and trying. Mr. Cowper, the then Chief Commissioner of Works, consented to the inventor laying down 100 yards of his new road on the Mall in St. James's Park, at the foot of the Green Park. The surface subsequently broke up under the heavy traffic, much to the surprise of the inventor. For some time he was puzzled, but at last he solved the mystery. It would appear that the roadway at each end of the experiment was macadamized at the time when the experiment was made, and inadvertently the contractor's workmen were allowed by the person in charge to pass their roller from end to end before the cement was properly consolidated. The consequence was that the crystalline structure of the cement being injured, the surface of the road was found to need repair through its yielding to the incessant traffic. It appears to have been repaired by a coating of two inches of macadamized stone, which was rapidly ground down on the hard concrete by the vehicles. Mr. Mitchell observes in his account of the failure of this experiment: "As the bottom was entire and consolidated, had a coating of two or three inches of concrete been laid down, with the required time to consolidate, it would have answered all the purposes contemplated, but the surveyor deemed it his duty to remove the concrete surface entirely, which was only done at great trouble by means of levers and iron crowbars."

Mr. Mitchell was, however, not to be beaten. All inventors must provide against failure in the early history of their improvements, and the lesson derived from the experiment made in the metropolis was, and will be, of use to him in the future. His third attempt was at Edinburgh, at St. George's bridge, and at the end of twelve months the roadway was reported to be sound and immovable, notwithstanding the heavy traffic which it is well know passes over this important thoroughfare. One little failure, however, occurred, through inexperience. Small hollows showed themselves at the end of the winter, at the joinings along the center of the roadway. These hollows were soon filled up, and the result has since been eminently satisfactory.

It has been objected to these pavements that they produce more noise than the ordinary roadways; but, while admitting this, it is urged that the noise from the vehicles, though greater, is different, being more of a ringing sound, as if the street were bound up with frost.

The question of cost is an important consideration. It would seem that the concrete road at Edinburgh cost 6s. 8d., and the paved road 17s. per square yard, in addition to 1s. 8d. per square yard for excavating and removing the old road, and watching. It must be remembered that the roadway was but small, and had the experiment been on a larger scale, the cost might have been considerably less. The cement being cheaper in London, the cost of concrete roads would be proportionately less. A firm of engineers in Edinburgh made experiments on Mr. Mitchell's roadway, by which they discovered that it enabled loads to be drawn at a much less cost in tractive power. Thus, we are told that, as the result of the superior evenness and solidity of the roadway, a wagon of two tons' weight ascending a gradient of 1 in 80 required a traction of 70 lbs., while on a common macadamized road, the same weight required a traction of 140 lbs. The difference of one-half is, of course, a wide one. Again, on a road with wheel tracks through new metal, 340 lbs. were required; and on a road newly covered with metal, 560 lbs., all the gradients being 1 in 80. This point of the conservation of power is an important one, and speaks favorably for the new road.

Undoubtedly almost everything depends, in the construction of these roads, upon the quality of the cement and the carefulness with which the work is superintended and done. The inventor holds that the Portland cement should be of the best quality, and tested to bear a tensile strain of 500 to 600 lbs. on a bar $1\frac{1}{2}$ in. square. The cement must be allowed time to harden; a month was found sufficient in Edinburgh. This adds to the difficulty of using the material in the metropolis, where the roads are required for use immediately they are laid. It has been suggested that cement blocks, properly tested, should be used, and this would obviate the difficulty we have pointed out. At any rate, we hope that Mr. Mitchell may yet be permitted to make another experiment in London, where we have reason to believe it would be as successful as in Edinburgh. Mr. Reid, C. E., has expressed his opinion that an engineer might, with duly prepared and tested cement blocks, re-lay the whole extent of London Bridge in fourteen days. Such an event may not be altogether impossible.

THE METRIC SYSTEM.

From a lecture by the Rev. JOSEPH A. GALBRAITH, F. T. C. D.

From the "Scientific Opinion."

The jurors of the International Exhibitions of 1851, 1855, 1862, and 1867, all agreed to recommend the general adoption of the metric system by civilized countries. The International Statistical Congress, held at Brussels, Paris, Vienna, London, Berlin, and Florence, reported in favor of its adoption. There is a permanent committee of the British Association, called the Metric Committee, whose object is to forward the adoption of this system, for the sake of the benefit it would confer upon scientific investigators, engineers, and students in the various arts and sciences.

The metric system is, at present, used throughout Europe and America by a population of 150,000,000 of people. Nearly 60 per cent of the total export and import trade of the United Kingdom is carried on with people using the metric system.

The fundamental principle of the metric system is that it should be international. This appears from the report of the Academy of Sciences, signed by its president, Cordorcet, and presented to the National Assembly in March, 1791, by M. Talleyrand. The report states that, after careful consideration of the question, the Academy had come to the conclusion, that every arbitrary consideration should be excluded from the proposed system; that it should not possess any feature which could raise even a suspicion of the particular interest or influence of France. In a word, the Academy desired so to frame the system, that if its principles and details alone, apart from its history, should descend to posterity, it would be impossible to divine by what nation it was designed or executed.

COUNTRIES IN WHICH THE METRIC SYSTEM HAS BEEN WHOLLY ADOPTED.

	Population.
France, with Algiers	40,500,000
Belgium	5,000,000
Netherlands and Colonies	23,000,000
Italy	24,000,000
Papal States	700,000
Spain and Colonies	21,000,000
Portugal and Colonies	8,000,000
Greece	1,200,000
Mexico	8,000,000
Chili	1,600,000
Brazil	8,000,000
New Grenada	2,000,000
Other South America Republics	3,000,000
	146 000.000

COUNTRIES IN WHICH THE METRIC SYSTEM HAS BEEN PARTLY ADOPTED.

	Population.
Switzerland	2,500,000
Hanse Towns	500,000
Denmark	3,000,000
Austria	37,000,000
	43,000,000

COUNTRIES WHERE IT IS PERMISSIVE.

	Population.
United Kingdom	29,000,000
United States of America	31,000,000
Prussia and North Germany	30,000,000
	90,000,000

Principles and Nomenclature of the Metric System.—1. It is international. Its framers intended it to be so, and so well carried out their principle, that nearly 200,000,000 people have already adopted it.

2. Its principal units are derived from natural standards; the dimensions of the earth, and the weight of water.

3. It is rational, because all its parts, proceeding regularly from the unit of length, are connected together by rational relations.

4. It is decimal, that is to say, all its parts are multiples or submultiples of the number ten on which our arithmetic is founded.

5. The nomenclature is simple, expressive, and well adapted for international use. It consists of only eleven words. The name of each weight or measure tells its own story, and as all the words are derived from the Greek and Latin languages, in which all civilized countries have an equal interest, no national sentiment is interfered with.

Unit of Length.—To establish the unit of length, the Commission appointed by the French Government proceeded to calculate the length of a quadrant of the earth, from the measured length of an arc of the meridian, the extremities of which were Barcelona and Dunkirk, stations which are nearly north and south, and comprise about 10° of latitude, situated very nearly equally on each side of the mean latitude 45° north. The linear standard used in this survey was the toise of Peru, so called from its having been used by Lacondamine, in the year 1756, in the measurement of the Peruvian arc. This toise or fathom was divided into 6 ft., the foot into 12 in., and the inch into 12 lines. The calculation founded on the measurement of the Barcelona-Dunkirk arc gave as the length of the quadrant of the meridian 5,130,740.75 toises, from which the number of lines may be calculated as follows:

5,130,740.75	Toises.*
6	
30,784,444.20	Feet.*
12	
369,413,330.40	Inches.
12	
4,432,959,964.80	Lines.

The ten-millionth part of this was selected as the meter or unit of length. Therefore

Meter = 443.296 Lines.

Unit of Land Measure.—The unit of land measure is the are, and is equal to a square having for its side a line of ten meters.

Unit of Capacity or of Liquid and Dry Measure.—The unity of capacity is the liter, and is equal to a cube having for its side one-tenth of a meter.

Unit of Weight.—The unit of weight is the gram, and is the weight of a cube of cold water having for its side one-hundredth part of a meter.

Multiples and Submultiples.—The multiples of these units are expressed by prefixes taken from the Greek language, and are as follows:

Deca,	signifying	Ten times.
Hecto,	"	Hundred times.
Kilo,	"	Thousand times.
Myria,	"	Ten thousand times.

The submultiples are expressed by prefixes taken from the Latin language, and are as follows:

Deci,	signifying	Tenth part.
Centi,	"	Hundredth part.
Milli,	"	Thousandth part.

* There is surely some mistake here.—Ed.

SYNOPTIC TABLE OF THE METRIC SYSTEM.

Units.

METER—ARE—LITER—GRAM.

10,000 times, Myria. 1,000 " Kilo. 100 " Hecto. 10 " Deca.		
	Unit.	
		Deci, 10th part. Centi, 100th " Milli, 1,000th "

Formation of Tables.—The tables of length, land measure, capacity and weight, are readily formed by placing the respective units in the place of unit in the synoptic table:

Length.	Land measure.	Capacity.	Weight.
Myriameter			
Kilometer			Kilogram
Hectometer	Hectar	Hectoliter	Hectogram
Decameter		Decaliter	Decagram
METER.	ARE.	LITER.	GRAM.
Decimeter		Deciliter	Decigram
Centimeter	Centiar	Centiliter	Centigram
Millimeter		Milliliter	Milligram

It may be observed that some of these tables are more extensive than others; according to the nomenclature they should be equal term for term, but practice has determined the limits, as given above.

Relation of Weight and Linear Measure.—According to the metric system, the unit of weight, or the gram, is the weight of a cubic centimeter of water; therefore, one thousand of these, or one kilogram, is the weight of a liter or cubic decimeter of water; one thousand kilograms is the weight of a cubic meter of water. This weight is called a millier, or metric ton.

Metric Units expressed in English Measure.—The following table of values is the result of exceedingly accurate measurements and calculations:

Meter = 39.370790 inches.
Are = 119.60333 square yards.
Liter = 61.02705 cubic inches.
Gram = 15,432.348 grains troy.

Approximate Equivalents.—The following table of approximate equivalents answers very well for calculations in which extreme accuracy is not required:

LENGTH.

64 meters = 70 yards.
25.4 millimeters = 1 inch.

LAND MEASURE.

1 are = 4 perches.
10 ares = 1 rood.
1 hectar = $2\frac{1}{2}$ acres.

LIQUID AND DRY MEASURE.

$4\frac{1}{2}$ liters = 1 gallon.
1 hectoliter = 22 gallons.

WEIGHT.

1 kilogram = 22 lb. av.
30 grams = 17 drams av.

LINEAR SQUARE AND CUBIC MEASURE.

10 meters = 11 yards.
10 sq. meters = 12 sq. yards.
10 cub. meters = 13 cub. yards.

How to make a Meter.—Measure off on a slip of wood 3 ft. 3 in. and 3 eighths, divide this length into ten equal parts for decimeters, into 100 equal parts for centimeters, and into 1,000 equal parts for millimeters.

This meter is larger than the standard meter by only one part in ten thousand, and may, therefore, be considered as practically accurate.

How to make a Liter.—Take a piece of card-board, and on it construct a square whose side shall be 3 decimeters; subdivide this into 9 square decimeters, cut away the corner squares, and bend up those which remain into a cubical vessel.

How to make a Kilogram.—Balance a liter on a pair of scales with an exact counterpoise; fill the liter with cold water, the additional weight which will be required to restore the balance will be a kilogram. One-thousandth part of this will be a gram.

Retention of the Pound Weight.—In countries which use the metric system, the pound is just as familiar as with ourselves. The half kilogram, or weight of 500 grams, is universally called the pound, and is used in retail transactions. If this weight be called, as it is in Prussia, the new pound, we shall have

10 new pounds = 11 lb. av.

Prices by the pound should, therefore, be increased by 10 per cent if we adopted the metric system. Since 10 meters = 11 yards, the same observation may be made as to prices by the yard.

Consequent Disturbance of Trade.—The prices of nearly every commodity are quoted by the

Hundredweight = 112 lb.
Ton = 2,240 lb.

These weights are only $\frac{1}{64}$th part less than the corresponding weight used in Continental business—namely,

Centner = 50 kilograms = $110\frac{1}{4}$ lb.
Ton = 1,000 kilograms = 2,205 lb.

The consequent change in quotations would amount only to $3\frac{3}{4}$d. in the £1; a change so trifling would cause little or no disturbance in daily business.

THE FORMS OF STEAMSHIPS.

From "Engineering."

At the time when the principal resistance to the motion of vessels through water was believed to be head resistance, or so-called midship section resistance—and the time is not so long ago—nearly all attempts at improvement in form consisted in fining the bow and stern; in diminishing the area of midship section, or rather in providing a given displacement by means of longer, narrower, and shallower ships; and, finally, by introducing Mr. Scott Russell's elegant refinement of wave lines. It was very long ago evident, however, that there was another resistance, viz: that occasioned by the adhesion of the water to the entire wetted surface of the vessel—a resistance now widely and well known as "skin friction." All resistance that was not head and stern resistance was undeniably skin friction, since there were no other known or conceivable resistances to be overcome. But while vessels were propelled by sails only, it was impossible to ascertain the real amount of power expended in driving them, and thus there were no means of ascertaining the relative proportions of the two kinds of resistance to each other.

It was possible, even then, however, to calculate nearly the amount of head resistance for a vessel of given midship section and given angle of bows at any given speed. A flat-fronted or square-ended bow, moving at any given velocity, would, it is true, carry before it a wedge of what may be called dead water, and although the identical water thus carried might be, from time to time, changed by internal currents, generated by fluid friction, this bow of dead water would divide and turn aside the water in front. The case is the same as that to be noticed on the up-stream side of bridge piers, where floating objects are seen to diverge from the general direction of the current, preparatory to their taking one or the other side of the pier, one hundred or even two hundred feet above the pier itself, according to the thickness of the pier and the rapidity of the current. But this does not alter the fact that all the particles of water in front of the bow, supposing them to be at rest, would, if fairly struck, without the diversion caused by the liquid bow of "dead water," be turned aside, at right angles, and with the same velocity as that of the vessel itself. Thus, if the velocity of the vessel were $17\frac{1}{3}$ ft. per second, corresponding to about $10\frac{1}{4}$ knots an hour, the water would be turned aside with the same velocity of $17\frac{1}{3}$ ft. per second, corresponding to a head of 4.6 ft., and this would occasion a head resistance of 2 lbs. per square inch over the whole midship section of the vessel. If the midship section of a sailing vessel of, say, 36 ft. beam and 18 ft. draught were 500 sq. ft., or 72,000 sq. in., the head resistance would be 144,000 lbs., and at the given speed of $17\frac{1}{3}$ ft. per second, or 1,040 ft. per minute, about 4,540 horse power would be required to overcome the head resistance alone. Supposing, also, that the stern were cut square across, the water falling in behind it would, on striking, be as much below the general level of the sea, and thus there would be a corresponding minus resistance, representing an additional 4,540 horse power, making 9,080 horse power requisite for propulsion, apart from skin friction along the bottom and sides.

This would appear an astonishing measure of resistance at so moderate a speed as $10\frac{1}{4}$ knots, and for a ship of such moderate midships section, but it is, we believe, correct. As soon, however, as we alter the bows and stern to a wedge form, the head and stern resistances diminish rapidly, in fact in proportion to the square of the sine of the angles to which the bow and stern are beveled. If these formed an angle of but 30° on each side of the keel, the bow and stern thus forming, each, an equilateral triangle, the head and stern resistance would be diminished to one-fourth of what has been estimated for a flat-ended bow and stern, supposed to strike and receive the water at right angles to their faces. If the bow and stern were, each, made twice as long as their width, giving an angle of 1 in 4, or 14° 30′, on either side of the keel, the water would be turned aside and afterwards replaced with but one-fourth the velocity estimated in the case of the square-ended bow and stern, and the power thus required would be but one-sixteenth that first estimated, the power required being always as the square of the velocity of lateral displacement. If the bow and stern were again beveled to an angle of 1 in 6 or 9° 30′, on either side of the keel, the length of bow and stern, respectively, being three times the breadth of beam, the head and stern resistance would be but the one-thirty-sixth part that first estimated; and if an angle of 1 in 8, or 7° 10′, were adopted, the head and stern resistance would fall off to but one-sixty-fourth that estimated for the square-ended bow and stern. It is thus that the head and stern resistances fall so rapidly, as the bows and stern are made finer and finer, and that they soon cease, as Mr. Phipps has shown in his letters, to form the principal resistance. But the resistance implied by a wedge formed bow and stern is a resistance involving the loss of dismissing the water, displaced laterally, with a final velocity sufficient to carry it beyond the mid-body of the hull, whereas it should fall to rest alongside. Every inch of motion of the displaced particles which carries them beyond the ship's beam is a direct loss of power. The fore body, therefore, is eased off by a curve connecting it with the mid-body to diminish the displacing motion, or, rather, to allow the displaced particles to drop of themselves into their proper places by expended momentum. Finally, by hollow water lines at the entrance, the shock, whatever it may be, of instantaneously giving to the displaced water its full lateral velocity is greatly lessened and nearly extinguished, by setting it gradually into a motion like that of a pendulum.

Following the same general principles in forming the stern, we reach a point where the head and stern resistances may be diminished, in some cases, to the one-hundredth part of those attending a flat-fronted bow and a flat-backed stern.

Simple and obvious as this general view of the resistances to the motion of vessels through water may appear, the subject is one which has very seldom, if ever, we think, been popularly treated, and it is one upon which misconceptions may be easily formed from the many apparent difficulties with which a first view surrounds it. If not a spontaneous, it is, at least, a not unwilling acknowledgement to say that some of these misconceptions have been embodied, before now, in our own columns, and Mr. Phipps, who has so well considered the phenomena of the hydraulics of marine propulsion has done good service in suggesting, in his own courteous manner, what was to have been said to the contrary.

If, then, as can be estimated with tolerable exactness, we know the effective engine power actually utilized in driving a steamship, or, in other words, its absolute resistance; and if we then find by calculation that the head and stern resistances form but a small fraction of this resistance, the remainder can be nothing else than skin friction, since, as already observed at the commencement of this article, there are no other known or conceivable resistances beyond those, of course, of wind, tide, and currents, to be overcome. It must be acknowledged that we have long ago passed that stage of improvement in the forms of vessels which left their resistance of form a minimum and their resistance of surface a maximum.

The New Wonders of the World.—Under the heading, "Mirabilia Mundi: VIII, IX et X," "Engineering" says: The Suez Canal, which, not a dozen years ago, was ridiculed here, in engineering England, as a visionary, if not an impractical, scheme, will be virtually completed this year, and Captain Tyler is already reporting to the Board of Trade upon the probable early passage of large ocean steamships direct from Port Saïd to Suez, on their way from Southampton to Bombay. After passing through the impossible stage, and landing safely on the improbable, this great work was said to be one of £. s. d., as, indeed, most works are, and money, it was said, could not be found to make it. But it will not have cost, according to authoritative statement more than £10,000,000 when completed, a cost not so very far beyond that estimated for the Metropolitan Railway system with its extensions.

The Pacific Railroad, completing the chain of railways 3,300 miles long, from New York to San Francisco, or, in other words, connecting the Atlantic and Pacific oceans, has already been opened this year, although in an incomplete state. But it is something that passenger trains are running daily over 1,721 miles of a continuous new line, made wholly within the last three years, and crossing a mountain range at an elevation higher than that of any other railway in Christendom.

The Mount Cenis Tunnel, as long, 7½

miles, as that part of the Thames, following all the windings, between London Bridge and Putney Bridge, is making rapid progress, and may already count as one of the wonders of the world. Yet even now, when so far advanced towards completion, the great tunnel affords room for the most doubtful speculation, the "Times" Paris correspondent dwelling gloomily upon the prospect of tapping a lake somewhere inside of the mountain!

Wonders never cease, yet the French Atlantic Cable, if successfully laid this year, as presumably it will be, will be no wonder at all, for are there not two cables like it already laid across the bed of the Atlantic?

We now perceive that no one of these great works possessed the fatal defect of impossibility; indeed, they almost appear as if, from the first, they were conspicuously practicable and simple in their character, requiring, of course, time and money, and, perhaps, just a *little* skill. None of them happen to be the works of English engineers, so we can afford to be somewhat complaisant — don't let us say patronizing.

But there is a work in prospect which English genius may yet achieve — and it will assuredly be by English genius if achieved at all—which, not in mere length, nor in geometrical magnitude, but in the stretch which it might impose upon the highest resources of the combined skill, patience, and courage which a whole institute of engineers ever possessed, will surpass any one of the great modern wonders of the world which we have enumerated. That work is the Channel Tunnel. It is a work depending upon a great engineering IF, and a great financial IF, and possibly, although we trust not, upon a great political IF. Of the three *ifs*, possibly the engineering *if* is the greatest, although we would wish to believe otherwise — indeed, there *are* reasons for believing otherwise. In that submarine valley between Dover and Cape Grisnez, twenty miles across, and 200 ft. deep, can the chalk be depended upon as continuous? Mr. Hawkshaw's borings have probably already well-nigh settled that. A single deep fissure, filled with sand, would pour in a torrent, under a pressure, in mid-channel, of at least 100 lbs. per square inch, sweeping everything beneath it. One is tempted into a wide field of geological speculation upon the subject, but it may be dismissed for the present with this hasty suggestion.

IRON SHIPBUILDING.

Abstract of a paper before the London Association of Foremen Engineers, by Mr. James Rae, and of the discussion, by Mr. E. J. Reed.

The frequent disasters to iron ships must be in most cases attributed to defective construction. Iron ships, as a rule, were built with frames of that metal, the outer skin being formed of plates of iron and the inner one of timber planking. This latter served as a floor for the reception of the cargo, but it was no safeguard in the event of the outer skin being penetrated. Great stress had sometimes been put upon the efficiency of bulkheads. Practically they were really of little value. Steamships were usually furnished with four or five. These were supposed to be water-tight. Too frequently it was found, in the fell moment of peril, that they were nothing of the kind, and that after a collision it might be said of the vessel that she contained "water, water everywhere," whilst the pumps were incapable of discharging it. Bulkheads were, in ninety-nine cases out of the hundred, illusory and deceptive protectors of iron ships. Vessels of this kind, as now constructed, were calculated well enough for ordinary service under favorable circumstances, but were totally unfitted to contend against the extraordinary accidents which often befell them at sea. It was quite true that the past twelve years had witnessed great improvements in the construction of iron vessels, both as regarded the quality of the material used and in its mode of application. The author of the paper introduced at this point some startling facts which had come under his own notice when engaged as manager for a large shipbuilding company, and which demonstrated very forcibly the haphazard modes of construction commonly practiced not many years since. Mr. Rae also took some credit to himself for remedying the evils to which he referred, and especially considered himself entitled to commendation for having been the first to introduce the plate-planing machine into the shipbuilding yard. This apparatus was now almost universally employed instead of, or as supplementary to, the shearing machine, and Lloyd's rules distinctly specify that all "butts" shall be planed. The economy and the excellence of iron shipbuilding had been enhanced in a remarkable degree by the use of the planing machine.

The author next addressed himself to the question of internal defects in the construction of iron ships, and pointed out more particularly the weakness which was formerly observable in regard to the head and stern. In 1858 he decided to commence an improved system of connecting the stem and stern of vessels entrusted to his building with the keelson. The keelson plate was, in reality, carried up the stem and stern to a considerable height, and the solidity of the vessel was thus increased three-fold. The plan was patented, but, by a legal quibble, the inventor derived no advantage in a pecuniary sense, but, on the contrary, sustained a heavy loss in the shape of costs. The Admiralty had adopted the scheme without recognizing its promoter, and it was now public property, for all who were engaged in iron shipbuilding know its value and used it as freely as the Government.

Mr. Rae then proceeded to say that all iron vessels ought to be built with an internal as well as an external iron skin, the latter of course being of the greater thickness. Both skins should be made perfectly watertight. Between the inner and the outer skins a series of bulkheads, say 9 ft. apart, and extending from gunwale to gunwale, should be affixed. The spaces between the bulkheads should be filled in with asphalte, so as to prevent water passing from one space to another. Such an arrangement would add but little to the original cost of the ship, whilst it would increase her strength fully fifty per cent.

Mr. E. J. Reed, Chief Constructor of the Navy, commenced the discussion which followed the paper, and in doing so said that he agreed with its author as to the generally faulty construction of iron ships as built some few years since. Even now he thought that legislation might be beneficially employed in regard to the construction of iron ships for commercial purposes. He considered that the Admiralty had not acted unfairly towards the reader of the paper. That gentleman had no doubt discovered the weak points to which he had referred in regard to the stems and sterns of the older iron ships, but so had many others, and it was hardly to be expected that so self-evident an improvement could come under the prohibitory provisions of letters-patent.

As to the double-skinned vessel with asphalte "filling" between the bulkheads, he had little faith in it. The ship in such case would be permanently loaded very much to her detriment, whilst the contingent advantage was problematical. He wished also to say that in every instance where bulkheads were used in the royal navy, their water-tight qualities were tested by hydraulic pressure.

EXPLOSIVE AGENTS.

Abstract of a paper read before the Royal Society by F. A. Abel, F. R. S.

The degree of rapidity with which an explosive substance undergoes metamorphosis, as also the nature and results of such change, are, in the greater number of instances, susceptible of several modifications by variation of the circumstances under which the conditions essential to chemical change are fulfilled.

Excellent illustrations of the modes by which such modifications may be brought about are furnished by gun-cotton, which may be made to burn very slowly, almost without flame, to inflame with great rapidity but without development of great explosive force, or to exercise a violent destructive action, according as the mode of applying heat, the circumstances attending such application of heat, and the mechanical condition of the explosive agent, are modified.* The character of explosion and the mechanical force developed, within given periods, by the metamorphosis of explosive mixtures, such as gunpowder, is similarly subject to modifications; and even the most violent explosive compounds known (the mercuric and silver fulminates, and the chloride and iodide of nitrogen) behave in very different ways under the operation of heat or other disturbing influences, according to the circumstances which attend the metamorphosis of the explosive agent (*e. g.*, the position of the source of heat with reference to the mass of the substance to be exploded, or the extent of initial resistance opposed to the escape of the products of explosion).

Some new and striking illustrations have been obtained of the susceptibility to modification in explosive action possessed by these substances.

The product of the action of nitric acid upon glycerine, known as nitroglycerine or glonoine, which bears some resemblance to chloride of nitrogen in its power of sudden explosion, requires the fulfillment of special conditions for the development of its explosive force. Its explosion by the simple ap-

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* Proceedings of the Royal Society, vol. xiii., pp. 205 *et seq.*

plication of heat can only be accomplished if the source of heat be applied, for a protracted period, in such a way that chemical decomposition is established in some portion of the mass, and is favored by the continued application of heat to that part. Under these circumstances the chemical change proceeds with very rapidly accelerating violence, and the sudden transformation into gaseous products of the heated portion eventually results, a transformation which is instantly communicated throughout the mass of nitroglycerine, so that confinement of the substance is not necessary to develop its full explosive force. This result can be obtained more expeditiously and with greater certainty by exposing the substance to the concussive action of a detonation produced by the ignition of a small quantity of fulminating powder, closely confined and placed in contact with, or proximity to, the nitroglycerine.

The development of the violent explosive action of nitroglycerine, freely exposed to air, through the agency of a detonation, was regarded until recently as a peculiarity of that substance; it is now demonstrated that gun-cotton and other explosive compounds and mixtures do not necessarily require confinement for the full development of their explosive force, but that this result is attainable (and very readily in some instances, especially in the case of gun-cotton) by means similar to those applied in the case of nitroglycerine.

The manner in which a detonation operates in determining the violent explosion of gun-cotton, nitroglycerine, etc., has been made the subject of careful investigation. It is demonstrated experimentally that the result cannot be ascribed to the direct operation of the heat developed by the chemical changes of the charge of detonating material used as the exploding agent. An experimental comparison of the mechanical force exerted by different explosive compounds, and by the same compound employed in different ways, has shown that the remarkable power possessed by the explosion of small quantities of certain bodies (the mercuric- and silver-fulminates) to accomplish the detonation of gun-cotton, while comparatively very large quantities of other highly explosive agents are incapable of producing that result, is generally accounted for satisfactorily by the difference in the amount of force suddenly brought to bear in the different instances upon some portion of the mass operated upon. Most generally, therefore, the degree of facility with which the detonation of a substance will develop similar change in a neighboring explosive substance, may be regarded as proportionate to the amount of force developed within the shortest period of time by that detonation, the latter being, in fact, analogous in its operation to that of a blow from a hammer, or of the impact of a projectile.

Several remarkable results of an exceptional character have been obtained, which indicate that the development of explosive force under the circumstances referred to is not always simple, ascribable to the sudden operation of mechanical force. These were especially observed in the course of a comparison of the conditions essential to the detonation of gun-cotton and of nitroglycerine by means of particular explosive agents (chloride of nitrogen, etc.), as well as in an examination into the effects produced upon each other by the detonation of those two substances.

The explanation offered of these exceptional results is to the effect that the vibrations attendant upon a particular explosion, if synchronous with those which would result from the explosion of a neighboring substance in a state of high chemical tension, will by their tendency to develop those vibrations, either determine the explosion of that substance, or at any rate greatly aid the disturbing effect of mechanical force suddenly applied, while, in the instance of another explosion, which develops vibratory impulses of different character, the mechanical force applied through its agency has to operate with little or no aid; greater force, or a more powerful detonation, being therefore required in the latter instance to accomplish the same result.

Instances of the apparently simultaneous explosion of numerous distinct and even somewhat widely separated masses of explosive substances (such as simultaneous explosions in several distinct buildings at powder-mills) do not unfrequently occur, in which the generation of a disruptive impulse by the first or initiative explosion, which is communicated with extreme rapidity to contiguous masses of the same nature, appears much more likely to be the operating cause, than that such simultaneous explosions should be brought about by the direct operation of heat and mechanical force.

A practical examination has been instituted into the influence which the explosion of gun-cotton, through the agency of a detonation, exercises upon the nature of its metamorphosis, upon the character and effects of its explosion, and upon the uses to which gun-cotton is susceptible of application.

THE VENTILATION AND TRAPPING OF DRAINS.

From a paper before the Society of Arts, by JAMES LOVEGROVE, Esq., Assoc. Inst. C. E.

The subject embraces the ventilation of drains, the trapping of gullies, and the various modes adopted for preventing sewer air passing out of gully and drain inlets.

The author of this paper has been led to attach considerable importance to the subject of drain ventilation, in consequence of having, in many instances, observed in houses where sanitary works had been carried out, a larger amount of effluvia after the execution of drainage works than existed before. He therefore purposes, in order that the subject may be fully and fairly put before the Society, to refer to the various means by which sewage matter has hitherto been conveyed from houses; to notice the effect upon the air in drains of discharging sewage matter into them; to suggest a new mode of ventilation; and also to consider the means usually employed to prevent the escape of sewer air through gully and drain inlets.

Some twenty or thirty years ago, public sewers were permitted to receive waste and refuse waters only, the closet drainage being carried into cesspools. The wash-house sink discharged the waste on to the surface of the back yard, by a pipe which passed through a hole in the external wall; the other waste water flowed along an uncovered drain beneath the floor of the house, and thence over the surface of the footway into the side channel of the street, so that, at all times during the day, a dirty stream of sewage might have been seen flowing along the channel. The exhalations from the uncovered cesspool, from the soaked and saturated materials of the uncovered drain, and from the exposed stream of sewage in the street, were most offensive. A covered sewer along such a street was next introduced. Gradually, covered drains were constructed beneath the houses, and connected with the new sewer, but with untrapped inlets, and untrapped gullies were also formed in the street channels to carry off the surface water. Thousands of cesspools were next connected with the sewer by overflow drains, and these allowed the effluvia therefrom to escape through the inlet opening, and caused a nuisance as great, or nearly so, as existed under the original state of things.

The next step was that of abolishing cesspools, and fixing pan-inlets, in direct connection with the drain leading into the sewer. The result was that, although the nuisance arising from the cesspools had been removed, the effluvium escaping through the untrapped drains and gullies was increased tenfold. The cesspool had been a long-standing abomination before the water-closet was thought of as the readiest way of getting rid of the nuisance. But this remedy, though so universally adopted, should be regarded by all as one of a palliative character only, as it not only causes the pollution of our rivers, but requires more than half the water supply to keep the closets clean. It is, however, hoped that modes of collecting the excreta and the most valuable portion of town sewage, without destroying their valuable properties, will, ere long, be introduced, and that the sewers will simply be put to their original use of receiving waste and refuse waters only. The dry earth closet may be a step in the right direction, and should receive a fair trial, in spite of the few difficulties which have to be met with at the outset.

In inquiring into the causes of air currents, either from or within drains, it is suggested that the variable flow of sewage has a powerful influence on the air within the drain, whilst that produced by rainfall has still greater, and the variations of tempera-

No. of observations.	No. and sizes of drains.					Velocity in feet in five minutes.		Ingress or egress.	Remarks.
	18 inches.	15 inches.	12 inches.	9 inches.	6 inches.	Minimum.	Maximum.		
170				27		50	200	ingress.	
				1			1,000	ingress.	
				1			1,650	ingress.	
				14		50	100	egress.	
				1			250	egress.	
				1			400	egress.	
				125					quiet.
48					11	50	100	ingress.	
					8	50	1,600	egress.	
					29				quiet.
12			2			50	50	ingress.	
			2			100	100	egress.	
			8						quiet.
8		2				50	100	ingress.	
		1					150	egress.	
		5							quiet.

ture are another cause of displacement and renewal of drain air. The table shows a series of observations taken at the outlets of drains, at the points of connection with the sewer. They were taken by Biram's anenometer, and the results show that up and down currents of air are constantly passing to and fro. Whenever an up-current issues through a drain opening, it must be manifest that some of the inlets of such drains are untrapped, and, therefore, sewer air must be escaping through such untrapped inlets, to the danger of those who reside in the house. In the construction of gully inlets there are two principles which should be strictly observed, viz.:

1. To prevent, as far as practicable, the entry of road detritus into the sewer.

2. To prevent the escape of sewer air through the inlet.

Various methods have been adopted. Twenty different forms of traps in general use are all dependent on being constantly charged with water, and may be easily proved to be inefficient for the purposes for which they were designed, and for these reasons should be condemned. The sewer air is separated from the atmosphere by the ¼-inch of water, or at the most an inch, and a few days' dry weather is sufficient to untrap most of the gully inlets, as the water quickly evaporates to below the siphon-dip. This evaporation is aided, in many cases, by the absorbing power of the materials with which the inlets are constructed, and also by matters falling into them. These gully traps are often fixed in a narrow street close to the open doors and windows of the houses, and are, it is feared, in many instances, the cause of much ill-health. Traps constructed on this principle have been observed by the author in an untrapped condition, in Derby, Leicester, Windsor, and other places. Another form of trap, largely used for street gullies in the metropolis, is known as the shackle-flap, sometimes fixed at the end of a 12-inch or 15-inch length of pipe, and sometimes in the form of a square block. The flap and its seating form two plain metallic surfaces, and it therefore does not admit of partial separation of the surfaces, as the smallest possible opening made by the overflowing water separates the surface throughout, so that, while the water is flowing through the lower part of the valve, the sewer air escapes through the upper part. The flaps are sometimes fixed at the point of connection with the sewer; their action has been tested where thus fixed. A lighted candle has been held at the sides of the flap during the passage of water through the gully, and a strong current of sewer air was found passing through the upper part of the flap during the period of flow. The system adopted by the author is constructed on the two principles hereinbefore mentioned, and forms a combination of the siphon-dip and shackle-flap. It is made in two forms; one form having the appearance of a bent tube, nearly semicircular in shape, and inserted so that one end of the tube, called the siphon-dip, dips into the cesspit beneath the gully grating, and the other discharges into the outlet, the valve-flap being fixed within the tube. The other form is that of an oblong block of stoneware, having a 6-inch opening formed diagonally through it, so that the valve on the outlet side is from 1 to 2 inches higher than the opening in the block on the cesspit side, both on the same principle, but in different form. The siphon-dip prevents the escape of sewer air through the upper part of the shackle-flap during the period of flow, and the flap resists the upward pressure of the sewer air, thus effectually sealing the inlet. The pressure of the sewer air within assists in closing the flap, whilst the pressure on the inner face by the atmosphere opens the flap, and allows a refreshing current of air to pass into the sewer. This current is generally so strong as almost to blow out the light when placed near to the flap, and should be maintained, but so as not to admit of the escape of sewer air.*

The escape of sewer air into houses gave rise to the adoption of various forms of traps. For drain inlets, I believe the first trap used was the dip-trap—a brick cesspit formed usually about 18 in. square and 6 in. below the drain, the inlet on one side being separated from the outlet on the other side by a division of stone, slate, or iron, made to dip about an inch into the water of the drain. The well-known common siphon was an improvement on the old dip-trap for the main line of drain, and in a ventilated drain these are efficient, inasmuch as, from one source or another, they are always charged with water. This form of trap is used by the author in combination with an air tube and valve, the latter acting as a ventilator. The principle of the water-dip has been put into

* Gully and drain traps on this system are made by Mr. Jennings, of Lambeth.

various forms of drain inlets, but they all are dependent on a very small thickness of water for their action, and are quickly untrapped by evaporation, and then the result is precisely the same as if there were no trap at all. The common bell-trap is more frequently met with than any other form of trap. The mere film of water at the rim of the inverted bell is supposed to prevent sewer air passing through, but, generally speaking, when the sewers are in the most foul condition, that is, in the summer season, the required film of water is not in the trap, and it then forms a sewer ventilator. A piece of house-flannel, cotton, or other similar matter entering the bell-trap inlets, will often hang partly in the bell basin and partly out, and, by siphonic action, quickly draw off the water to a level below the rim of the inverted bell. These traps exist in almost every house, and are the cause of a large amount of illness. These remarks are applicable to all the forms of trap dependent on a constant film of water for their action, which are, consequently, not reliable.

[The paper then gives a number of examples of drains becoming untrapped in hospitals, residences, &c.; among others, the following:]

In a public hospital, near Portman-square, a brick drain in direct connection with the sewer passed sewer-air inwards so strongly as to blow out the flame of a candle. This drain continued through the building, and received in its way the raised sink-inlets, also the drainage from the lavatories, sinks, and water-closets on the upper floor. In this case, when water was passed from one or other of the inlets, it caused the contained air first to press against the water in the inlet water-traps, and, on reaction, to draw off sufficient water to untrap the inlet. Thus, through one or other of the inlets, air was generally escaping into the house.

In further considering the action of drain-traps, we will refer to a drain trapped at its outlet with a shackle-flap, and the several inlets trapped with the ordinary water-traps. When water is poured into a drain thus constructed, the result depends in a measure on the relative weight of the shackle-flap at the outlet as compared with the resisting power of the water-traps. If the flap be lighter, the pressure exerted on the air contained in the drain by the in-flowing water, will act on the inner face of the flap, force it open, and discharge a bulk of air into the sewer. Then, while the water is passing through the lower part of the flap, the sewer air will enter by the upper part, and thus the drain will be filled with sewer air, even while the water-traps are full. If one of the inlet-traps were unsealed, the air would pass through the unsealed trap instead of into the sewer. If the shackle-flap be the stronger resistant of pressure, the water poured into the drain will act on the surface of the water in the weakest of the water-traps, and impart to it a rocking motion, causing part of it to flow out of its basin. The atmosphere will also press on it, in the endeavor to take the place of the out-flowing water, and thus untrap the inlet, so as to allow the sewer air to enter the upper part of the shackle-flap during the period of flow. Then, if the outlet-trap be a common siphon, or the old form of dip-trap (which in principle are both precisely the same). then the sewer air will be entirely shut off, but the force of displacement of the contained drain air will most likely enter the house through the kitchen sink, as the air of the drains must escape somewhere, under the pressure of in-flowing water. In such a drain, the more water there is thrown into it, the more effluvia will escape. The slimy coating also of the interior of a long length of drain, is of itself sufficient to contaminate the contained air, no matter what fall the drain may have. In the methods just described, the one idea has been an unsuccessful endeavor to stop the opening from which the smell escaped, without inquiring if this or that opening is stopped, what will become of the foul air, what new state of things is produced, and what are the influences actually at work. Certain it is, that the more generally adopted of trapping inlet-drains favors the escape of sewer air into the houses.

Now, all that has been stated suggests that, in the trapping of drains, there must be provided—

1st. A ready and proper outlet for the escape of the drain-air when under pressure.

2nd. A means of supplying air to the drain, to follow the out-flowing water.

3rd. Such a construction of the inlet-traps as will effectually prevent the escape of drain-air.

The way in which these three principles may be applied is as follows: The outlet-trap is fixed at or near the point where the drain is connected with the sewer, and is made in one piece, with a siphon-dip, to shut off the sewer air, and an air-exit tube passing over the siphon-dip. Then, at the mouth of the air-tube a light metal air-valve is placed, so as to open outwards from the tube into the sewer on receiving a light pressure from within. Thus, when water is discharged into the drain, or a decided difference of temperature exists, the pressure of the air is exerted on the inner face of the valve, which then opens, and allows the drain-air to pass into the sewer. The siphon-dip, without the shackle-flap, is admissible at the outlet of a ventilated drain, as it is always charged with water. Then, at the several inlets are fixed valves to work freely, with siphon-dips behind them, excepting the water-closets and scullery-sinks. The valve shuts off the drain-air, whether there is water in the trap or not, and the siphon-dip prevents the escape of drain-air, during the period of flow, through the upper part of the valve. No amount of pressure from within the drain, or atmospheric influence from without, can affect the efficiency of these traps. Next, in any part of the drain (near the extremity is best) is placed an air-supply post, containing a light air-supply valve, which opens inward to the drain on a light pressure, so that when the water is emptied into the drain (having first displaced air through the outlet air-valve) flows out of the drain, it is followed by a supply of air through the air-supply port. The more water discharged into the drain, the more frequent will be the removal of air. In the application of this principle to a drain having inlets at a considerable elevation, in lieu of the air-escape at the outlet traps, an air tube is carried from the highest point of the drain to a height as far as possible from the windows and the influence of chimney down-draught. The inlets are secured by the same mode as that just previously described, a common siphon at the outlet, and the air-supply valve fixed near the outlet of the drain. By this mode a current of air is obtained from the lower part, passing through the drain, and discharging above the roof. In many instances air supply is obtained freely through the valve-sink inlets.

In the case of a house-drain connecting into a pipe-sewer, in order to obtain a ready access to the air-valve and siphon-dip, the air-tube is continued on to the surface side of the dip, where it receives a box, containing the air-exit valve. The air-tube thence continues down to the outlet side of the dip, and the air is discharged into the sewer.

The form of sink made for a garden-sink is adapted for yards, areas, stables, gardens, cellars, &c. A cheaper one for cottages is made in stoneware, with spigot-ends at the valve-mouth to fit the socket of an ordinary drain-pipe, and finished with a socket-flange at the top, to receive a perforated iron or stoneware plate; the workman laying the drain can thus complete his work without sending for the bricklayer, laborer, bricks, and cement, to form the receiver usually constructed beneath a bell-trap or 5-hole sink.

The form used for stables and large yard surfaces is made wholly of iron. An iron nozzle-piece is attached to the outlet, forming a spigot-piece, and is made to fit into an ordinary socket-pipe.

Scullery sinks are very difficult things to secure, because of the rapid accumulation of grease. Valves are inadmissible, except in the form of a gully-trap and receiver, which are found to be safe and effectual. The pipe from the sink should, in that case, be continued so as to dip into the receiver. In small scullery-sinks a deep form of garden-sink, without the valve, would be much cheaper, and is found to be effectual. The valve is also unsuitable for a closet-inlet, as the paper clogs the valve, and the siphon-trap of the closet is never dry, and is not subject to variation in a ventilated drain.

A few words on the subject of water-closets. It is as well to state some objections to the form of closet in general use. The well-known valve-closet, formed by a valve about 2 in. in diameter, closing at the lower part of the pan, is liable to leakage at the valve, and, when this occurs, the corrupted air contained in the iron chamber beneath escapes into the house.

A large number of copper and zinc pan-closets are in use. We have first the stoneware basin, then a swing pan of copper and zinc, then a large iron pan beneath these, and this iron pan has a surface of metal coated with foul matter equal to $4\frac{3}{4}$ ft., and in contact with the external air. The common closet-pan contains one-third of a foot super., but the most cleanly closet I have met with is one made by Mr. Jennings, which was in use at the last Great Exhibition, exposing a surface of $1\frac{1}{8}$ ft. only in contact with the soil, giving off the least amount of effluvia. A common stoneware pan is preferable by far, in the matter of cleanliness, to many of those costly contrivances that are in daily use.

In conclusion, the author hoped that the importance of this subject would be an excuse for the length of this paper.

COAL BURNING ENGINES IN ENGLAND.

In a series of articles on Railway Economy in "Herepath's Railway Journal," a history of the devices for preventing smoke and burning coal economically, is given, and the present practice is described.

The means that have been chiefly employed are extended fire grate surface, so as to have a thinner fire and afford a larger area for the passage of the air; and stepping or inclining the grate at a considerable angle, so that the coal being introduced close to the fire door, may gradually travel forwards as it parts with its gases and becomes incandescent, and thus ignite the gases that pass over it from the fresh fuel; making a double fire box with the same object; the application of a combustion chamber with or without fire-bricks, which become heated and ignite the gaseous products as they pass through or over them; and combined with these, various plans for admitting the requisite supply of air above the fuel, either by deflecting it as it passes through the fire door, or by introducing it through tubes or air passages.

Gray and Chanter in 1847 divided the fire box into two parts and admitted air above the fire. Dewrance improved upon this idea in 1845, and McConnell again in 1853, both these experimenters using the combustion chamber. The trouble, up to this time, was to ignite the gases distilled from the coal. In 1855 this was *perfectly* accomplished by Beattie,* but at the expense of maintaining and transporting some tons of fire-bricks. Cudworth's inclined grate came into some favor about this time. In 1856 Messrs. Dubs and Douglas applied a deflecting feather proceeding from the back of the fire-box towards the tube plate, to cause the gaseous products of the coal to descend on the incandescent fuel and thus become ignited, and Mr. Dubs, in connection with Mr. Evans, in 1857 added to this a movable inclined grate, which could be raised or lowered at will, for the proper management of the fire.

In 1857 Mr. Yarrow introduced a flat arch of fire-brick in the interior of the ordinary fire-box, placed at a considerable inclination, the lower side commencing just under the lowest row of tubes, projecting upwards until within eight or ten inches of the roof of the fire-box; tubes were also provided in the tube plate under the arch as well as in the fire-door for the admission of air.

The gases would thus be deflected, and have to pass round this brick arch, being at the same time heated and supplied with a fresh dose of oxygen from the air rushing in through the tubes. Considering that this was simply a modification of the fire-box originally designed to burn coke, the results were very satisfactory. A very similar plan was introduced by Mr. Jenkins on the Lancashire and Yorkshire railway, but in place of a fire-brick arch he employed a curved deflector of cast iron similarly placed, but perforated near its outer edge with numerous holes. He also employed air tubes at the front of the fire-box under the fire-door, as well as at the back under the tubes.

In 1857 Mr. D. K. Clark devised a system of forcing air into the fire-box through air tubes placed at the sides by fine steam jets directed from the outside and passing through the air tubes, which acting in a similar way to the blast pipe of the engine, caused currents of air to rush into the fire-box with great force. The orifice of the jets is but $\frac{1}{16}$ inch in diameter, the air tubes $\frac{1}{2}$ in. This simple arrangement was found to completely prevent smoke without any further appliance. It has been at work satisfactorily on several lines, and has been adopted on all the locomotive stock on the Great North of Scotland railway. Whether the steam which is introduced into the fire-box performs any office beyond the mere mechanical one of drawing the air in along with it, in producing any new chemical combination which would facilitate the combustion of the volatile gases, does not seem to have been investigated. It would, however, to some extent warm the air, and perhaps make good the loss from the use of the steam in this manner; and it is supposed that the steam has some power to precipitate the carbonaceous particles which remain unconsumed; at any rate the plan seems to be very economical. There is one advantage possessed by this plan over most others, viz., that by the use of these steam jets when the engine is in a station the smoke can be prevented, as they act in a more direct manner than a jet in the chimney.

In 1858 Mr. Wilson introduced a system

* See "European Railways," Colburn and Holley, for details.

of air tubes which extended from the fire-box right under the boiler to outside the front of the smoke-box. This arrangement would partly effect the object of Mr. Clark's steam jets when the engine was running, since the air would then be driven through these tubes into the fire-box with considerable force. Mr. Ramsbotham also about the same time provided two small doors in front of the fire-box, under the barrel of the boiler, with regulating valves for the admission of air above the fuel, and just above these openings he placed an arched fire-brick deflector, something similar to that of Mr. Yarrow.

Messrs. Lee and Jaques also introduced a somewhat similar arrangement as regards the projecting fire-brick arch, but they combined with this a deflector fixed to the top of the fire-door. This deflector projected into the fire-box sloping downwards, the door itself being underhung and provided with a valve for the admission of air, the opening and closing of which was regulated by a sector. The air being drawn in through the valve in the fire-door, would by means of the deflector be directed downwards, and mix with the gases, and their combustion be effected by impinging on the incandescent fuel, and the brick arch fixed against the plate.† About the same time Mr. Frodsham employed a deflecting plate over the fire-door, but the brick-arch was omitted, and in place thereof two steam jets were introduced, one on each side, into the front part of the fire-box, impinging downwards upon the fuel. Mr. Douglas employed a deflector with the same object, but he combined with it an inclined fire grate of larger area, which involved a longer fire-box, and of course necessitated an alteration in the boiler or the construction of new engines.

† This deflector in front of the fire-door, generally without the bricks, is now much employed in England with quite good results.—Ed. V. N. M.

THE LOCOMOTIVE OF THE FUTURE.

From "Engineering."

It would be difficult for the most enthusiastic engineering futurist, if at all practical, to point out the direction in which any radical improvement in the locomotive engine is to be sought. As long as the resistances opposed to the motion of trains are what they are, and as long as the present rates of speed are maintained, the amount of locomotive power to be provided cannot be lessened. There is not the slightest chance that any other agent than steam will be employed, in our generation at least, to produce this power. Compressed air locomotives, hot air locomotives, vapor of alcohol locomotives, and electro-magnetic locomotives have all been tried, and they have failed for perfectly obvious reasons—reasons which should have been foreseen by any one possessing the least knowledge of the motive agencies thus called into play. Steam, then, being our only resource, it can be generated only by the combustion of fuel, and this fuel must obviously be the cheapest available. With us, the cheapest fuel is coal. We can none of us see the way to anything cheaper. Petroleum may be burnt easily enough—its use is entirely practicable, but it is too dear. Even were it cheaper than coal, its use would involve no important constructive modifications of the locomotive boiler, and none whatever in the working machinery.

And what can be simpler than the locomotive boiler as it is. A large amount of heating surface *must* be provided, and how could it be better provided? There are few who would not desire to welcome improvements were they possible, but it will prove no easy task to improve upon the principles, or the construction, of Neville's multitubular boiler of 1826, as successively improved in detail by so many locomotive engineers since George Stephenson first brought it into practical work. The locomotive boiler has been made in almost every possible form. There have been twin barrels, double fire-boxes, round fire-boxes, combustion chambers, mid-feathers, return tubes, water tubes, water grates—indeed, every imaginable modification of the original structure to which all successful practice has again returned.

We have no doubt that steel will yet take an important part in locomotive boiler construction, as it has already done in that of fixed boilers. The Bolton Steel and Iron Company appear at last to have produced Bessemer steel boiler plates which can be thoroughly depended upon in large quantities, and there are fire-boxes of a somewhat kindred material—Howell's homogeneous metal—which have perfectly withstood nine years' use on the Scottish Central Railway. In all this, however, there is no new principle, and the most that can be hoped from steel, is somewhat greater economy in repairs, and the possibility of working higher pressures of steam, should it prove desirable to do so.

In the motive machinery of the locomotive, beginning with the regulator and ending with the driving wheels, no improvements beyond those of mechanical detail appear to be possible. No possible application of the principle of the rotary engine holds out the least hope.

As for the rest, the locomotive engine is a carriage merely. So much total weight, divided by so much permissible weight per wheel, and we have the necessary number of wheels, to be coupled or not, according to the requisite adhesion.

It is only as a carriage that we see much room for improving the locomotive. It does appear anomalous that with from one hundred to two hundred wheels beneath a train, none of them loaded beyond 3 or $3\frac{1}{2}$ tons, a permanent way of twice the strength otherwise necessary should be required to carry 7 tons each on a pair of driving wheels. It is equally inconsistent that with wheel bases of from 8 to 10 ft. under the wagons and carriages, from 15 to 18 ft. should be necessary for the engine. Were the maximum weight per wheel not more than 4 tons, and the maximum wheel base in any one unalterable rectangle no more than 10 ft., it is almost beyond dispute that a very considerable economy would be effected in the maintenance of the permanent way.

PATENTS.

The abolition of protection for inventions has frequently been discussed in England, but the late advocacy of such a step in parliament, and by persons of importance and influence, has created an unusual excitement among the classes most interested, which has found copious expression in the London scientific press. For a government to broadly declare that the rights of property in inventions should cease, would be as foolish and suicidal as to broadly declare that there should be no property except in material, tangible things—that the intangible results of one man's mental labor should be the property of all men. Under such a law few inventions would be made, simply because they could not be protected. Successful inventions, that benefit mankind and advance civilization, are almost invariably the fruit of costly experiment. The first ideas of the greatest inventors are crude. Watt, Bessemer, Morse, Goodyear, Ransome, Howe, Corliss, Roberts, Siemens, Ericsson—none of these men perfected their works at the start. Their success is due vastly more to their persevering warfare against "practical difficulties"—to the pluck and business capacity of themselves and their partners, than to their original discovery or combination of certain materials and forces. Is it reasonable to suppose that Bessemer, for instance, would have worked for five years against all manner of difficulties, and at a cost to himself and associates, of many thousands of pounds, to make the pneumatic process a success, if the sole fruits of his brain and fortune were to be then snatched out of his hand, without one penny of compensation? Yet, just that labor and fortune had to be risked by somebody, or the pneumatic process would have been perfectly impracticable and useless. Inventions cannot be protected by being kept secret—there is no use in arguing this point—and if they were kept secret, how far would the public be benefited by them? If the patent laws are abolished, all the men who have the capacity and means to *work out* great improvements, will have to do so at their own expense, for the benefit of their rivals in business, and without hope or right of reward. When business men present one another with checks and pig iron and cotton and farms and machinery, inventors may be expected to work without protection. In short, if the patent laws are abolished, the stimulus to working out inventions and making crude ideas practicable, will be taken away—there will be no farther reason why men should invent, and they will stop inventing. They may, indeed, start ideas, generally undeveloped, but they will not and cannot, on any other ground than general philanthropy, undertake the cost of making their ideas practical and useful, and this is what the law recognizes as the subject of a patent.

Only two apparently reasonable grounds of objection to property in inventions have been put forward. The first is, that only one in a hundred inventions is useful. Well—is the public injured because a man obtains a patent for a useless invention, any more than it would be if he spent the same money on a useless building? In the former case he neither creates *nor destroys* any value. But it will be said that the inventor of a useless machine "ties up" combinations and parts which another man could, if they were free, make useful. Nothing could be more at fault than such a statement. The patent law contemplates a machine that will perform the functions claimed. If it will not, the patent is invalid, and the parts and combinations *are* free. If it will, and the functions are desirable, then the invention is not useless, and the inventor is entitled to just what he invented—no more. If another inventor makes an addition that enlarges or betters the functions, or cheapens the operation, he is entitled to just that improvement—nothing more—and the parts and combinations that are tied up by the first patent, are no more unfairly tied up than the first inventor's house and shop are—they do not belong to the second inventor—he found them the possessions of another.

"But says the objector—"Many patents claim more than they can accomplish—the *untying* of parts and combinations thus involved is a tedious and costly process of law." This is true, but the embarrassment is the inventor's, not the public's. If inventors are willing to go to such cost to establish their claims, the public is not only uninjured by the process, but it is largely benefited by the result. Suppose that property in patents were unlawful, so that inventors could not test the validity of their works in the courts, and would have no inducement to do so if they could—how much better off would the public be then? They would not, indeed, have to pay any royalty to either contestant, nor would there be any improvement to use. They could reap by hand and go on foot at ten times the cost of machinery, and save a small fraction of their loss by not paying royalty.

The main argument against the patent laws is, that where the public possesses, in common, all the elements of the knowledge out of which an invention may proceed, it is unjust that he who happens to have a week's or a month's start over his fellows in arriving at an important practical application of that knowledge—an application which, it is assumed, scores of others are seeking, and which, it is furthermore assumed, some of them would, in a short time, have certainly attained—it is unjust, the argument repeats, that the first one who finds out what others *might* have found out, should be permitted to block up the road against them. In answer to this, "Engineering" says: "In other words, although the world had waited six thousand years or so for a given invention, it was certain that a dozen or more inventors were as near to attaining it at a given time as would a dozen competing horses be near to the winning post at Epsom within five seconds of the finish. All this is merely begging the question, if it be not, indeed, a mere display of idle sophistry."

This objection, furthermore, shows the gravest ignorance of the history and probabilities of patents. As we have before stated, useful inventions are in the rarest instances, if ever, complete and perfect inspirations. An idea—for instance, the idea of the telegraph, or of the pneumatic process, may be instantly conceived—but undeveloped ideas are not the subjects of patents. Before the law recognizes them, they must be clothed in working bodies, so that the law can see that they will perform the functions claimed. Now, the ideas of decarburizing cast iron by air and by ore, were not only known a century ago, but were practiced before the reader of this paper was born, and have been, in various partially-developed shapes, patented from time to time for years. Surely we have all had not only an untrammeled chance to invent the Bessemer and the Ellershausen processes, but we have had a very close guidance to them in the experiments and practice that preceded them; and we can no more fairly quarrel with the law that protects them to Bessemer and to Ellershausen, than we can with the law that keeps our hands out of the strong-boxes of Stewart and Vanderbilt. We have had just as fair a chance, under the law, to make the fortunes of the latter, as we have had to make the inventions of the former.

But above and beyond the *policy* of protecting patents, there is the question of *right*. Upon this Mr. Greeley says in his political economy, now in course of publication: "The rights of those who create intellectual property are less clearly defined — perhaps less capable of unerring definition — than those of the producers or transformers of material substances; yet they seem to me not less real, beneficent, and defensible. Let us suppose that four brothers commence responsible life with equal patrimonies, equal capacity, and like habits of industry, temperance, and frugality. Twenty years afterward, one of them, who has devoted his energies to farming, has a fine estate, a commodious dwelling, a handsome herd of cattle, a good collection of implements, a library, and all the material elements of independence and comfort. A second has addressed himself to the construction of locomotives, and has done as well thereby as his farming brother. A third has given himself up to the study of mechanics and engineering, and has, after many disappointments, perfected a new steam-engine, whereby the power required to move a train or boat of so many tons, at a given rate per hour, is reduced at least twenty-five per cent. The fourth has addicted himself to literature, art, and poetry, and has produced a book which one hundred thousand of our people annually read, deriving pleasure and instruction therefrom which they would rather pay him for than forego. I ask why this inventor, and this author, have not as fairly earned, and are not as justly entitled to, the price that others prefer to give rather than forego the advantage or pleasure derived from their products, as are their brethren, the farmer and the locomotive-builder, to a like remuneration for the use of *their* products? If, as Thiers forcibly says, 'The indestructible foundation of the right of property is labor,' then, surely, the right of property in Elias Howe to that combination of the needle with the shuttle which gave practical existence and value to the sewing machine, of Alfred Tennyson to 'The Princess,' 'Maud,' 'In Memoriam,' and 'The Lotus Eaters,' is as perfect as any right of property can be. For the craftsman merely fashions, adapts, or recasts, materials co-existent with the earth, and which may be regarded as in some sense once the common property of mankind; while the inventor, the poet, builds into the void space, makes chaos luminous, and adds potentially, and as it were by original creation, to the enduring wealth of mankind. I cannot perceive how or why his right of property in his products is not at least as perfect and pervading as that of the maker of a locomotive, the grower of grain.

"I have considered what has been urged in favor of a restriction of this right of property to the material thing wrought upon—to the particular locomotive built by the inventor, the author's manuscript copy of his poem—and it seems to me palpably absurd. For what the inventor has labored twenty years to perfect is not the single, particular locomotive on which he expended his handiwork, but *all* locomotives to be thereafter built—his efforts were incited and upheld by a desire to make *all* locomotives henceforth less costly or more efficient. This he has achieved, or nothing; herein he has succeeded, or not at all. Once completed, the machine whereon he has labored so long may accidentally take fire and burn to ashes, yet no one, surely, would thence infer that his labor had been in vain.

"As to the abolition of the patent system, which has of late been influentially advocated, I shall be more easily reconciled to it when I learn that it is to be swiftly followed by a repudiation of *all* rights of property whatever—or, more strictly, of all legal guaranties and defenses of such rights. Whenever the laws of my country shall refuse to protect the inventor, they should, in simple consistency, bid the land-owner, the bond-holder, the merchant, the banker, 'Take care of yourself, and of all that you call your own!' Assuredly, no man's right to the wild lands conceded to his ancestor by a European monarch who never saw, and knew not how, even to bound them accurately, can be better than that of Eli Whitney was to his cotton gin, or that of Daguerre to photography. When these shall be successfully denied, be sure that *no* rights of property can be secure.

"'Then, why not make patents and copyright absolute and perpetual?' is often asked. I answer, there are *no* absolute rights of property. The land you bought of the Government yesterday may be taken from you for the bed of some highway or railroad to-morrow, and you have no redress. *All* rights of property are held subordinate to the dictates of national well-being; and the Government will batter down or burn to ashes your house, if it shall have become (through no fault on your part) a harbor or defense of public enemies, and make you no compensation therefor. I only insist that intellectual property shall be recognized by law as standing on a common foundation with other property and equally accorded the protection of the State and the respect of all who hold property no robbery, but justly entitled to deference and support from the wise and the good."

In the discussion of this subject "Engineering" reviews, at some length, the more important inventions now in successful use, and they are of a thousand times more value to the public than to the inventors, large as the aggregate royalties must be. We quote the remarks of our cotemporary, not only to show how little legislators and anti-patent law agitators, like Sir Roundell Palmer (to whom these considerations are addressed), are likely to know about what they are talking, but also to remind the profession and inventors of the greatness of the field in which they are called to labor, and of the inspiring success already achieved.

"Of modern inventions there are, literally, hundreds which, we have reason to believe, would have failed to establish their value to their authors, and especially to the public, but for the protection of the patent laws. Of hundreds of these, we firmly believe Sir Roundell knows absolutely nothing at all, and this, although many of these very inventions have received his own fiat as Attorney-General. Were it possible for him, and, we will add, for Lord Stanley as well, to leave, for a week, the oppressive atmosphere of politics and law, and devote one-half of that time to a rapid survey of recent successful inventions, both would form views very different from what they expressed in the House of Commons last Friday evening. Each pitched upon the steam engine, the electric telegraph, and the screw-propeller as distinct substantive inventions; and yet it is absolutely impossible to say who 'invented' either of them, although it is easy to name from half a dozen to a score of inventors, in the respective cases, who contributed greatly to the success of these inventions, and each of whom deserved, so that his claims were justly and exactly specified, such reward as a patent best affords. To any one who knows the history of these great inventions, it is absurd to say that James Watt, Professor Wheatstone, and Mr. Francis Pettit Smith were THE respective 'inventors,' although, in each case, they opened more ground, and to better purpose, than any inventors who had preceded them. James Watt, taking the steam engine in the imperfect, but yet effective, state in which he found it, invented the separate condenser, the steam jacket, the parallel motion, the sun-and-planet motion, and other details, and in his best practice his engines consumed 10 lbs. of coal per indicated horse power per hour. At the present time, non-condensing engines, the 'invention,' possibly, of Trevithick, work without separate condensers, without steam jackets, without parallel motions, and without sun-and-planet wheels, with a consumption of but from 3 lbs. to 4 lbs. of coal per horse power per hour. To enumerate the patented meritorious improvements in the steam engine would require much space, but Sir Roundell Palmer would find no difficulty in obtaining a knowledge of them were he to place himself in communication with any of our leading mechanical engineers.

"In other branches of engineering the modern, patented, *meritorious*, inventions are so numerous that it is difficult to bring them within the limits of a catalogue *raisonné*. We might mention five hundred as easily, but for limits of space, as one hundred, and as it is certain that none of us know the full width of the field of invention, there are probably other hundreds of valuable inventions of which a single writer may be ignorant. Again, for the principal patents obtained for important inventions many subsidiary patents are granted for details useful in working them, just as the 'Bessemer process' is protected by, in all some dozen of patents, each of which possesses a certain value, and is therefore meritorious.

"It would be a long list were we to record the modern meritorious inventions relating to the manufacture and working of iron. Quite apart from the more recent and suspicious patents obtained by Heaton, Radcliffe, and Richardson, and on the other hand apart from the grand series of patents in Bessemer's name, there are, among patents, in force or lapsed, Siemens' furnace, which melts iron of any quality as if it were wax; Aitken's kilns for coking carbonaceous ironstones; Bourdon's (Morrison's) coal-washing machine, whereby excellent coke is made from the most sulphurous refuse known as coal slack; While's continuous blooming mill; the steam hammer; the self-acting steam hammer; Ramsbottom's duplex steam hammer; Davies's steam striker, the most pliant, adaptable and intelligent steam hammer yet contrived; Ryder's forging machine, as effective as it is noisy; Haswell's, and Shanks', and Kohn's hydraulic forging presses; Garforth's steam riveter; Bertram's admirable system of gas-welding boiler, beam, and girder plates, so well worked out by the Butterley Company; Root's blower, the finest blast engine for foundrymen yet schemed; Woodward's steam jet cupola, which dispenses with mechanical blowers of every kind; Jobson's, Howard's, and the Anderston Foundry Company's systems of machine moulding; Hetherington's system of plate moulding; George Scott's superlatively beautiful system of mechanical wheel moulding; Deakin and Johnson's process for punching steel tubes—a process which, when we reported that a $10\frac{1}{2}$ in. hole had been punched 4 ft. deep through a 3 ton ingot appeared incredible to many of our readers; Hawksworth and Harding's even more wonderful process of cold "drawing" steel tubes, of any and every section, from hollow ingots; and, finally, Westwood's hydraulic press for bending the thickest armor plates, even up to 14 in. thickness. Were it not that Sir Roundell Palmer and Lord Stanley had delivered themselves so authoritively upon the whole range of invention, we should not have presumed to ask them how much they know of any one of the inventions we have mentioned. Unless "coached," we will venture the assertion that, if examined, competitively, they would both be found absolutely ignorant of nearly every one we have named, and yet each of these patents deserves, and properly managed, is likely to realize what either Lord Stanley or Sir Roundell Palmer might consider a very handsome fortune. And without the protection of a patent no man of business, in his senses, would care to work them at all, unless *en amateur*.

"Then there is another wide class of inventions relating to railways and railway rolling stock. There is the fish-joint—Mr. Bridges Adams's fish-joint after all the hubbub raised about it eight years after the expiration of his patent; the cast-iron pot sleeper (poor Greaves!) Ransome's and Vickers' crossings; Arbel's stamped wheels; Mansel's wood wheels; Beattie's clip fastening for the tyres; half-a-dozen oil-tight boxes; Clark's and Fay's continuous brakes; Sterne's capital buffers; Saxby's signals, which, we sincerely believe, have, by this time, saved the lives of ten thousand of Her Majesty's subjects; Ransbottom's trough for supplying tenders while on the way; ditto, his safety valve, and, ditto, his lubricator, both good things of their kind; Naylor's excellent safety valve; Bourdon's magnificent invention, though after all akin to Salter's balance, for weighing steam; Giffard's dynamic paradox, known as the Injector, and Schau's simpler and cheaper edition; Green's useful invention for drawing tubes from brass, and, finally, an invention of great intrinsic worth—Dudgeon's tube expander. How much do you know of all these, or any of them, Sir Roundell? Don't think us impertinent.

"Turn which way we may, we find almost innumerable recent, meritorious patents. In civil engineering we have Mitchell's screw pile, which has saved untold thousands of pounds in the cost of fixing uncertain foundations in India; Dr. Pott's system of pneumatic sunk cylinders; Hoffman's annular kilns for burning bricks; Dennet's fireproof flooring, now adopted in all the principal buildings in progress in the kingdom; and Clayton's well-designed machinery for brickmaking.

"In stone-working we have (and we should be sorry to be without) Blake's stone-breaker; Holmes's stone-dressing machine; Ransome's grand invention of artificial stone — an invention possibly worth more than Columbus' discovery of San Salvador; M. Sommelier's (*Anglice*, Mr. Butler's) tunneling machine; and, finally, Mr. Doering's and Mr. Lowe's machines for the same purpose.

"In connexion with the cotton manufacture less can be said. It is an industry which admits of but moderate progress, unless some new Hercules comes to our aid. Mr. Richard Roberts *was* a Hercules in this branch of engineering. There are Wellman's self-stripping cards; Leigh's top rollers; Hetherington's wonderfully simplified mule; the Blackburn "Slasher;" Messrs. Harrison's astonishing improvement upon all the space, tediousness, dirt, and cleaning of the dressing machine that had gone before it; and, finally, Bullough's loom patents, which have added a million of money to the wealth of Lancashire. To these may be added, with a qualified opinion of their merits, a nameless number of cotton gins; and in this and kindred branches of invention, there is not so industrious a patentee as John Platt, M. P., whose authority is quoted against patents, but who is, himself, an insatiate patentee, as well as an enterprising appropriator of ideas, supposed to be covered by patents in other men's names.

"Then comes the old class of patents relative to grinding flour. First there is the decorticator, worth a million in good hands; but, possibly, before it, the grain drier, upon the results of which so many fortunes hang. Again, there is Bovill's patent, renewed, against which so many millers fought, and to which so many surrendered. Then there is Golay's diamond machine for dressing millstones, sold for ever so many thousands of pounds, Brackshaw's grain elevator, and, going back for some years, Goucher's capital beaters for thrashing machines.

"In steam-agriculture there have been such improvements that we hardly know how to begin. The grand brain who did more for steam cultivation than any thousand men now living was John Fowler, long since in his grave. Sir Roundell Palmer, we presume, would, were it in his power, annihilate the industry growing out of Mr.

Fowler's inventions. His steam plough, his clip drum, his slack gear, are all unique, and long settled practice has proved that their value might be counted rather in millions than in thousands. And no industry he had to fight harder for existence: fights of which Sir Roundell probably knows nothing at all, for, had he known of them, he could not, as a gentleman, have spoken as he did last Friday evening.

"Then, again, in connexion with steamships. There are Cunningham's self-reefing topsails; Trotman's anchors; Clifford's boat-lowering apparatus; McFarlane Gray's steam steering gear; Robert Griffith's big boss, two, or three-bladed screw propeller; the engine-room indicator; Morton's ejector-condenser; Robertson's ashes ejector; and, to go from little things to great, Penn's trunk engines, and, of far more value than anything else ever invented in connexion with the screw engine—wood bearings—one among the grandest inventions of the present generation.

"Again comes another class of invention, viz., those for lifting and hoisting. Among these Edwin Clark's hydraulic graving dock stands first in importance; and, next to that, the various plans for hydraulic jacks, as well as Weston's pulleys, and the derrick crane made by Bowser and Cameron.

"But among the valuable miscellaneous patented inventions who shall draw the line? There are the patents for Dr. Dauglish's aerated bread; the American sewing machines; Anglo-Franco velocipides; Chappuis' daylight reflectors; Bunnett's coiling shutters; Betts' capsules; Wheatstone's private telegraph; Wheatstone's crytograph; Richards' indicator; Dunbar's apparatus for charging and drawing gas retorts; Perin's band saw; Chatwood's safe; dozens of inventions of breech-loading rifles; the Manchester water meter; Bailey's oil tester; a lot of American inventions for gas regulation and gas carburation, as well as for tin-lined lead pipe, the latter manufacture based upon the "flow of solids," commercially worked some years before M. Tresca's ingenious researches at the *Conservatoire des Arts et Métiers*, in 1866. There is the magnetic anti-incrustator, Siemens' gyrometric governor, Mallet's buckle plates, the Abyssinian tube well, Lloyd's fan, Robertson's frictional gearing, Dellagana's paper stereotype moulds, Gaine's parchment paper, Young's paraffine oil patent, Moncrieff's gun carriage, Hugon's gas engine, Armstrong's beautiful dove-tailing machine, Robert's elegant "diffusion" process for making sugar, Seyrig's centrifugal machine for drying sugar and other substances, the revolving magnetic machine for separating iron from brass turnings, Needham and Kite's yeast press, Harrison's ice-making machine, Carr's beautiful disintegrator, Peet's valve, Chatterton's compound for submarine cables, Webster's ferro-zinc paints, Moule's earth closets, Liernur's sewage system, Sillar's precipitating compound for sewage, Worssam's silent feed, Palliser's bolts, Batho's nut shaper, Sellers' bolt cutter, Perkins' sealed heating pipes, Porter's governor, Armstrong's hydraulic machinery, coal cutting machinery, Upward's drilling apparatus for gas mains, Garside's electograph engraving machine, Livesey's newspaper folding machine, various excellent refrigerators, King's malt measurer, and so on, in an almost endless list.

"Valuable as these inventions are, it has required a vast aggregate expenditure of time and money to induce the public to believe in, and adopt them. None, assuredly, knowing the task would have undertaken it without some hope of substantial reward, and patents appear to be the only rewards available. The inventions enumerated bear no proportion in number to the hundreds of useful modifications and combinations of modern machinery which are valuable rather for their simplicity and convenience than for any distinctive mechanical principle."

MARINE ENGINE PROGRESS.

From "Engineering."

Not middle-aged engineers alone, but comparatively young engineers as well, have had occasion to remark the wonderful rapidity with which the marine engine practice of any given period may become obsolete. The grand old side-lever engines of twenty years ago, or for that matter ten years ago, are fast becoming curiosities possessing a high degree of archæological interest. It will not probably be long before the 100 in. cylinder, 12 ft. stroke engines of the Scotia, only finished in March, 1862, will be replaced by screw engines, as has been done already in the case of the Persia. We have only to look back to 1847 to find but 156 steamers built and building in the British Navy, none of them exceeding 1862 tons, or 800 nominal, equal only to about 1500 indicated, horse power. The Greenock, the

Phœnix, the Rattler, the Fairy, the Bee, and the Dwarf were the only screw vessels, although the Amphion, Arrogant, Conflict, Dauntless, Desperate, Encounter, Euphrates, Megæra, Minx, Niger, Rifleman, Sharpshooter, Simoom, Termagant, and Vulcan—all screws—were in progress.

There is little reason to doubt that the opinions of marine engineers were as fixed and as strong, in 1847, as they are now, and then it was then believed that science and skill had done well nigh all that was practicable for the improvement of the marine engine. The steam was low and the speed was slow; the former from 5 lbs. to 10 lbs., the latter from 140 ft. to 260 ft. of piston per minute. The Alecto with 4 ft. 6 in. stroke, made but 14 revolutions per minute in regular work, or 126 ft. of piston, and even the Avenger, with 650 horse engines, 6 ft. stroke, made but 13 revolutions or 156 ft. of piston per minute. The Dee, with 200 horse engines, 5 ft. stroke, made but $12\frac{1}{2}$ revolutions, or 125 ft. of piston per minute. The Thunderbolt, with 300 horse engines, 5 ft. stroke, made but 15 revolutions, the Salamander, with 220 horse engines, 5 ft. stroke, made but 14 revolutions, and even the Victoria and Albert, with her original 400 horse engines, 6 ft. stroke, made but 17 revolutions of her 30 ft. wheels, corresponding to but 204 ft. of piston per minute.

There were many who disbelieved in the screw altogether, and its introduction into war ships was partly if not greatly due to the circumstance that the screw engine and propellor could be kept wholly beneath the water line, and that the deck was left clear for its whole length for armament. As for merchant steamers, it was long before steamship owners would listen to any arguments in favor of the screw.

It was even doubted whether screw engines could be practically worked at the high speed required by the screw, and gearing was often employed, as in some cases it is still. With injection condensers, and the old forms of flue boilers, steam of more than 10 lbs. per square inch was considered out of the question at sea; expansion was seldom practiced to any extent, and superheating was reckoned a costly and needless refinement, if, indeed, it had been thought of at all. The whole ground opened by the introduction of the screw was beset with difficulties, and but few were willing to believe that these could ever be overcome. The screw vibrated greatly, and came well nigh shaking the stern post out of the ship, and it was next to impossible to keep the screw shaft tight in the stern tube. Direct double-acting, full stroke air pumps, too, knocked their valves to pieces very quickly.

Marine engine improvement has consisted in doing just what twenty years ago was reckoned impracticable or inexpedient. The tubular boilers that were to give so much trouble by salting and leaking are now in universal use, and a flue boiler of 1850 would be reckoned a curiosity. The pressure of steam has been carried to 25 lbs. or 30 lbs. in regular work, while Mr. Elder's boats, and the Sirius, engined by Maudslay, are worked to 50 lbs. The piston speed has been carried, as a maximun, to 600 ft., and even 650 ft. per minute. Indeed, Mr. Bourne once worked a single cylinder engine of 3 ft. 6 in. stroke at 100 revolutions per minute. Superheating is now practiced with advantage and a good degree of expansion attained, in some cases with compound, or high and low pressure engines. Surface condensation, with all the cost, weight, and bulk of the tubes, and the difficulty, once encountered, of keeping them tight, as well as the danger, at one time so imminent, of corroding the boilers, is now a firmly established fact. Double-acting air pumps, making 75 double strokes, and 600 ft. of bucket per minute, work as easily and silently as the old air pumps, worked, off the beam or side-lever, at 80 ft. or 100 ft. with only but 15 or 20 double strokes per minute. The vibration of the screw has been well-nigh stopped by Griffiths' improvements; its stern bearing is now the most durable of all, since Mr. Penn applied wood bearings and the dynamic performance of large screws of fine pitch is in all respects equal to the best results obtained from paddles, while the machinery required to drive it is, of course, far lighter in respect of weight. Were we now to return to Boulton and Watt's old practice of 7 lbs., effective cylinder pressure per square inch, and 204 ft. of piston per minute for a $4\frac{1}{2}$ ft. stroke, it would require a pair of engines of 29 ft. 6 in. (354 in.) cylinder to develope the power of 8,500 horses, indicated on the trial of the Hercules. The revolutions would be $22\frac{2}{3}$ only per minute, requiring gearing in the ratio of about $3\frac{1}{4}$ to 1 to get up the 72 revolutions actually attained by the Hercules' screw. No comparison possibly could better mark the progress already made in marine engines. But if we address ourselves to an inquiry as to the limits of further improvement, we are confronted by seeming impracticability or impossibilities, such as stopped the way twenty years ago. To what point may the pressure be yet carried in practice? To 100 lbs., or more? Rowan worked 130 lbs. at sea; but his boilers gave trouble. Of course, with very high steam, superheated and condensed after exhaustion, a rate of expansion of 12 or 16-fold is practicable. As for piston speed, it may, possibly, be yet increased to the rate occasionally attained in locomotives, say to 900 ft., or even 1,000 ft., per min.; but we are all disposed to be incredulous as to the continuance, and especially the economy of such speeds. But, as abstract facts, we do know that steam engine economy is to be sought in high pressures, high speed, and high expansion.

It is a question whether the hot gases escaping at the chimney might not be advantageously forced into the boiler, below the water line, and be thus made to give off their heat. For every ton of carbon burnt from 6 to 7 tons of water are evaporated, while, also, $3\frac{2}{3}$ tons of carbonic acid are sent up the chimney at a temperature of perhaps 600°. That there is a considerable loss here is indisputable. The only question is, how may it be prevented, the presumption being that the cost of securing this waste heat would be greater than it would be worth when saved. Air, too, forced through a heating apparatus into the water in the boiler, or into the steam, would possess a theoretical advantage, and we hear of one or two patentees who are already experimenting in this direction, among them Mr. Richard Eaton, of Nottingham.

STEAM ON CANALS.

PROPULSION BY A FIXED WIRE ROPE AND CLIP-DRUM — EXPERIMENTS IN BELGIUM.

From "The Engineer."

A series of highly interesting experiments, or rather a general exhibition of the first line of considerable length, on which a new principle—the application of wire rope and clip-drum for river navigation — has proved practically successful, took place on the 4th and 5th inst. between Liège and Namur, in Belgium. The governments of England, France, Prussia, Austria, Wurtemberg, Holland, and Belgium, sent their special engineers; the Suez Canal Company, and steam navigation companies from the Danube, the Elbe, the Rhine, and the Rhone, were represented, and the presence of gentlemen from almost every country in Europe proved the importance which must be attributed at the present moment to all successful improvements in the methods of inland navigation on rivers and canals.

The Meuse has, between Liège and Namur, a length of nearly seventy kilometers (forty-four miles), leading through one of the principal coal districts in Belgium. The river forms one of the most important links of the long chains of canals and streams which connects Belgium, and particularly Antwerp, with Paris. A company, the Société Anonyme Liègeoise de Tonage, received a year and a half ago the concession for supplying the system patented by Bon. C. de Mesnil and M. Eyth to this line, and began their operations by laying an iron wire-rope of 1 in. outside diameter on the bed of the river. There are eleven locks to pass, which do not interrupt the continuous length of flexible rail thus placed in the axis of the whole water-course. Small holes are provided in the gates near the sill, so that the wire passes through the locks without interruption, and the gates being opened are perfectly free to be moved by the machinery. The only places where the rope is actually fixed or moored are two temporary ends at Liège and Namur, everywhere else it follows in a comparatively slack state all the bends and curves of the center line of the river. The mechanical principle of the system now consists in mounting on the tug-boat which carries the machinery a clip-drum, vertical or horizontal, which takes hold of the rope, the boat taking it up from the river bottom by suitable pulleys near its bow, and dropping it again near the stern into the water. The clip-drum, turned by the steam machinery, will thus haul the boat along the so-called fixed rope, pulling, in fact, on the weight of the wire and the frictional resistance of the same on the river bottom. In principle, therefore, the idea is the old one of chain navigation, as applied during the last twelve years or so on the Seine. But the practical difficulties which prevented the more general introduction of the latter, in spite of the great advantages inherent in the principle, are avoided in the new methods to so considerable a degree that M. Eyth's system seems to be destined to raise again inland navigation to the relative importance which its physical peculiarities warrant, and which it has, in most cases, lost by the introduction of railways.

The first tug of the Société de Tonage started on the line on which the experiments took place about a year ago. It is an iron boat, flat-bottomed, of twenty meters length, four metres width, 2.25 meters depth of hold, drawing 0.95 meters, and carrying a 14-horse power horizontal, double-cylinder, high-pressure engine. This engine works a vertical clip-drum on the side of the boat, of 6 in. diameter, over which, by means of two guide pulleys of the same diameter, the wire rope takes half a turn. The machinery was constructed, like that of the greater number of cable tugs now in Belgium, in England, by Messrs. John Fowler & Co., Leeds, who have made the construction of this sort of boats one of their specialities.

The speed of the clip-drum can be altered by suitable gear, thus giving ten, five, and two and a half kilometers, or rather more than one and a half miles per hour, to the tug. The first was intended to be used in towing down stream; but it was found that, with long trains in sharp bends, it could not be worked safely, and that the speed exceeded the requirements of the trade. The gearing proper to it was therefore removed. The speed of two and a half kilometers is only used in winter, for towing up-stream in the most rapid currents, which may amount, in certain places of the river, to ten or twelve miles an hour. The greatest amount of work done by this tug is, if going up-stream, at the rate of four miles an hour against an average current of two or three miles. Working with the full power of two 7¾-in. cylinders, 12 in. stroke, seventy revolutions, 80 lbs. or 90 lbs. pressure, it towed 1,500 tons of freight, as taken in ten boats of varying burdens; also, on another occasion, 1,000 tons of freight in eighteen boats more or less freighted. During winter the tug worked against currents, which the 45-horse power passenger steamers of Seraing were not able to overcome; 400 to 500 tons freight were taken in three boats, with the speed of two and a half kilometers, keeping thus the navigation open during a season which, up to now, was considered lost for the boat interest of the Meuse.

In consequence of the great delays at the locks, if towing considerable trains, the average mileage of the tug per day is small, amounting only to about forty-five kilometers, and being about double of what is done by horse towing on the same line. But the Belgian government, being satisfied of the beneficial influence this enterprise already effects on the movement of the river, have now decided to increase the dimensions of the locks, so that in future a whole train will be locked through at a single operation. So the mileage may be raised in future to fifty or sixty miles a day easily.

The coal consumed per day of ten hours was about half a ton, the ton costing 11½f. on the boat. There are five men on board, a captain or pilot, two sailors, an engine driver, and a fireman, and the total monthly working expenses amounted to about 600f. (£24). In towing 800 tons thirty-five kilometers per day, which may be considered at the present moment an average performance of the tug, the daily receipts are under the present tariff of 0.006f. per ton and kilometer (about one-third cheaper than horse towing for hire), 168f. Now the tug requires two days to go the seventy kilometers from Liège to Namur, and comes back frequently empty in one day. It has, therefore, twenty working days in the month, which pay, and the whole monthly receipts (if nothing is to be towed down stream), are 3,360f. (£134). Three more tugs are now in the possession of the company, of which two were successively tried during the experiment. They worked, especially in the sharp bends and considerable currents above Seraing, with regard to hauling and steering, with a steady ease which left nothing to be desired. It was generally feared that sharp bends with strong currents would be fatal to the system. These tugs are five meters longer, carry engines of 20-horse power, and differ in their constructive details considerably from the original type. They are all provided with an auxiliary screw, so that they can moor independent of the rope if required. This gave, some weeks ago, an opportunity of carrying out a very interesting experiment. The whole power of the engine can be brought to bear on the screw, and in that case the propeller was able to tow a 250-ton boat against the average current of the river, but no more. Working by means of the wire rope, she towed with ease five times as much at the same rate. It must be said that the form of the tug and the dimensions of the screw are not the most favorable for the propeller, and some 20 or 25 per cent more might be got out of more suitable proportions. Still, taking in account everything in this direction, there remains an effect of the engine about three times greater when working with the clip-drum than if using the screw.

Besides the line on the Meuse, there are now wire ropes on the Canal de Chaleroi, in Belgium, on the Canal de Beveland, in Holland, and on the Canal de Terneuze, which connects Ghent with the Schelde, and a short experimental rope for the Rhine. Considering the short time the idea has had for its practical development—the first experimental machinery being made in Leeds in 1866—these results speak for its importance and the undoubted success it has obtained on the lines in actual operation.

THE MANUFACTURE AND USE OF PORTLAND CEMENT.

BY DR. W. MICHAELIS.

Condensed and translated from "Polyt. Centralblatt."

Cements may be divided into two classes, the Roman cements and the Portland cements. The Roman cements are made from earths found ready in nature, especially in the Jurassic rocks. Their name was given to them by Parker, who was the first to use the limestone nodules of the island of Sheppey for the preparation of a water-mortar or cement, which is very similar to the mortar made by the Romans from puzzolana. Portland cements are generally water-mortars that are prepared artificially by grinding and mixing different natural substances. When hardened, they resemble in color and durability the celebrated Portland stone. They have, therefore, been designated by the same name by Aspdin, the inventor of the first artificial cement.

The principal distinction between Roman cement and Portland cement lies not, however, in their origin, but in their different physical condition, caused by different methods of calcination. Roman cement is a fine dust-like powder, partly of a light, partly of a dark reddish-brown color. It absorbs carbonic acid and water eagerly, and cannot, therefore, be stored for a long while. Portland cement, on the contrary, is a powder consisting of fine crystalline scales of a dark-grey, somewhat greenish, color, much heavier, absorbing carbonic acid and water less rapidly, so that it may be stored for some time. It is calcined at a considerably higher temperature than Roman cement.

Portland cements are considered the best water-mortars. Being artificially prepared, they can be obtained more homogeneous and uniform than the Roman cements, which vary too much in their composition.

The following analyses of some Roman and of some Portland cements show this distinctly:

ROMAN CEMENTS.

	1.	2.	3.	4.	5.	6.
Lime	58.38	55.50	47.83	58.88	68.8	78.31
Magnesia	5.00	1.73	24.26	2.25	2.3	3.60
Silicic acid	23.83	25.00	5.80	23.66	18.5	13.81
Alumina	6.40	6.96	1.50	7.24	5.7	} 4.86
Peroxide of iron	4.80	9.63	20.80	7.97	4.1	

PORTLAND CEMENTS.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Lime	59.06	62 81	62.81	60.33	61.64	61.74	55.06	57.83	55.28
Silicic acid	24.07	23.22	23.22	25.98	23.00	25.63	22.92	23.81	22.86
Alumina	6.92	5.27	7.66	7.04	6 17	6.17	8.00	9.38	9.03
Peroxide of iron	3.41	2.00	2.54	2.46	2.13	.45	5.46	5.22	6.14
Magnesia	.82	1.14	1.15	.23	......	2.24	.77	1.35	1.64
Potassa	.73	} 1.27	.77	.94	......	.60	1.13	.59	.77
Soda	.87		.46	.30	......	.40	1.70	.71	......
Sulphate of lime	2.85	1.30	......	1.52	1.530	1.64	1.75	1.11	3.20
Insoluble clay and sand	1.47	2.54	1.32	1.04	1.28	1.13	2.27	......	1.08

ORIGIN OF THE ABOVE ROMAN CEMENTS.

No. 1. From a triassic limestone near Rüdersdorf.
2. From limestone nodules of the island of Sheppey.
3. From a triassic limestone, covering the strata of lead ore, near Tarnowitz.
4. From Hausbergen.
5. From Metz.
6. From Holkin Mountain, near Holywell Flintshire.

ORIGIN OF THE PORTLAND CEMENTS.

No. 1. English cement from White & Bro.
2. From Stettin.
3. From Wildau.
4. From Wildau.
5. Pomeranian Star cement.
6. From Stettin.
7. English cement.
8. From the Bonn Mining Company.
9. From Kraft & Sanlich, at Perlmoos.

MANUFACTURE OF PORTLAND CEMENT.

Suitable limestones and certain kinds of clays are selected, mixed intimately in certain proportions, and calcined at a high temperature. The carbonic acid gas separates from the lime at a moderate red heat. But the mixture for Portland cement has to be subjected to a higher heat, because the hydraulic properties of the cement increase, to a certain extent, with the temperature at which it is calcined. It ought to be softened by the heat, but not so much as to assume the dense structure of a melted mass. This is effected at a white heat. The clay is thereby completely decomposed through the action of the lime, and silicate and aluminate of lime are formed. The calcined mass contains, besides these two compounds, which are its principal constituents, smaller quantities of silicate of alcali, silicate and aluminate of magnesia, and, perhaps, some sulphate and phosphate of lime.

The calcined mass is ground fine, mixed with a little water and worked into a paste. Cement thus prepared hardens more and more, the longer it is exposed to water, or to atmospheric air. Good Portland cement gets as hard as fluor-spar, and equals the best limestones in solidity and durability.

SELECTING AND MIXING THE MATERIALS.

Any kind of carbonate of lime is fit to be used in the manufacture of Portland cement. Marble, limestone, chalk and marl may be used. Chalk and marl often include foreign matters, such as flints, feldspar, sand, which have to be removed by washing.

The clay used must be of a certain chemical composition, which can be seen from the following analyses of celebrated kinds:

	1.	2.	3.	4.	5.
Silicic acid	68.45	60.06	59.25	60.00	62.48
Alumina	11.64	17.79	23.12	22.22	20.00
Peroxide of iron	14.80	7.08	8.53	8.99	7.33
Lime	.75	9.92	.....	4.18	6.30
Magnesia	.....	1.89	2.80	1.60	1.16
Potassa	1.90	2.50	1.87	1.49	1.74
Soda	2.10	.73	1.60	.72	.37
Sulphate of lime	.....	.60	2.73	.89	.60

ORIGIN OF THE ABOVE CLAYS.

No. 1. The celebrated Medway clay.
2. From the Prussian Province of Saxony
3. From Pomerania.
4. From the Upper Hartz Mountains.
5. From the Province of Brandenburg.

It is to be seen from the above analyses that the clays most adapted for the manufacture of cement contain considerably more silicate of alumina than kaolin does. Lime and clay have to be mixed very intimately. If this condition is not fulfilled, a good cement can never be obtained. The most perfect method of doing this is to mix them when suspended in a large quantity of water. However, the success of the manufacture depends not only on a thorough mechanical mixing, but also on the proper chemical composition. A careful examination of a large number of good Portland cements has shown that the proportions of the three principal components ought to be within the limits indicated by the following two examples of composition:

I. 80 equivalents of Si O^2 (silicic acid).
210 " " Ca O. (lime).
27 " " Al^2O^3 (Fe^2O^3) (alumina and peroxyde of iron).

II. 30 equivalents of Si O^2 (silicic acid).
230 " " Ca O (lime).
15 " " Al^2O^3 (Fe^2O^3) (alumina and peroxide of iron).

Supposing the sesqui-oxydes to play the part of acids, these two compositions correspond to the formulæ:

$$\text{I. } 10\ Si\ O^2\ (R^2\ O^3) + 20\ Ca\ O$$

(10 equivalents of silicic acid and sesqui-oxydes, with 20 equivalents of lime).

$$\text{II. } 10\ Si\ O^2\ (R^2\ O^3) + 24\ Ca\ O$$

(10 equivalents of silicic acid and sesqui-oxydes, with 24 equivalents of lime), which represent the limits of the composition of good Portland cement, and are of great value in preparing the mixtures of lime and clay.

The following facts will give an idea of the hydraulic properties acquired by the single components of cement, when they are mixed with other components and calcined: Silicic acid and lime are the most important components of cement in quantity and quality. When mixed together and calcined they form a compound which hardens under water. Not only amorphous silicic acid produces this effect, but also crystalline quartz, when heated with lime to a white heat. Carbonic acid affects and decomposes silicates of lime. The artificial silicates resist this decomposition the better, the more compact and dense the silicic acid was, in its raw state. Silicic acid and alumina do not alone combine chemically in water at ordinary temperatures after being calcined together.

Lime and alumina have a considerable affinity for each other. When mixed and heated they combine, and form hydraulic compounds, which harden with water perfectly well, especially when they have been produced at a high temperature. When compounds of alumina with one, two or three molecules of lime are finely pulverized and mixed with a little water, they become binding at once and form hydrates, which get very hard under water. By mixing the aluminate 2 Ca O, Al^2 O^3 with 30, 60 and 80 per cent of sand, Frémy obtained a mass that assumed under water the hardness and firmness of the best stone.

Lime and peroxyde of iron form a compound when calcined together. This compound is, however, less hydraulic than the aluminate of lime.

Calcined magnesia alone hardens well with water. It also forms with silica good hydraulic compounds.

Silicates of alcali are also useful in the process of hardening.

Sulphate and phosphate of lime do not aid the hardening, and may be considered as noxious ingredients, when present in considerable quantity.

CALCINATION.

The mixture of raw materials, made according to the principles above developed, is formed into pieces of uniform size (bricks), which are dried in the air and calcined. The furnaces used for calcining are generally kilns from 40 to 50 ft. high, and from 7 to 12 feet wide. Three or four feet above the ground they contain a strong grate, consisting of single bars, which can be removed when the calcination is completed. The calcined and slightly glazed mass of bricks slides down by itself in cooling, and is then extracted. The kilns are charged with alternate layers of fuel and cement bricks. The regular shape of the bricks allows of charging the kiln in such a manner that the escape of the gases can take place uniformly, over the whole section of the furnace, to effect a calcination as uniform as possible. Coke is generally used as fuel, because it is purer than coal; the sulphur contained in the latter would give occasion to the formation of sulphate of lime. If, however, raw coal is used, the kilns must have such a construction that the fuel does not come in contact with the cement, and that only the gases produced by the combustion pass through the furnace. The annular ovens, recently patented by F. Hoffmann and A. Licht, are used with great success for calcining cement, as well as bricks, lime and pottery. In these ovens the cement also comes in contact with the fuel, but a much smaller quantity of the latter is required, and the greater part of the ashes is gathered in the charging tunnels and does not mix with the cement.

A proper temperature in calcining is a very important matter. Cement calcined at too high a heat looses entirely its property of binding. The proper intensity of heat has to be found out by experiments for every single mixture. The denser the raw materials are, the higher the heat required. Mixtures prepared from compact limestone or washed chalk require a higher temperature than those prepared with light and porous kinds of carbonate of lime. The higher the temperature required, the higher the kilns have to be constructed. The temperature varies easily to an observable extent in kilns not holding over 150 tons. But the limits within which the temperature may vary without injuring the product are pretty wide. The hydraulic quality of the cement increases with the intensity of heat used in calcining. However, this is only the case to a certain extent. When overheated, cement gets too compact, and its capacity of hardening then decreases. A white heat is the proper heat for the calcination of Portland cement. If it is heated higher, it begins to run, and is then unfit for use. The best method to judge about the temperature existing in the furnace is to take samples of the cement under treatment from time to time. As the color of the cement changes with the increase of heat, the samples taken from the furnace will show by their color and appearance how far the process is advanced, and make it possible to regulate the temperature properly. The following will explain this:

The limestone looses its carbonic acid at a low red heat. At the same time the lime begins to decompose the clay. When a good red heat is kept on for an hour the mass becomes yellowish-brown, and can then be dissolved in diluted hydrochloric acid, the larger grains of quartz excepted. The capacity of the mass for hardening is, however, small yet. It gets hot, when mixed with water, and falls to pieces, when exposed to the air, like ordinary lime. With the increasing temperature the mass gets darker brown, more resisting to atmospheric influence, more capable of hardening, less liable to develop heat when mixed with water; all of which proves that the lime combines, chemically, more and more with the silicate. When the temperature is increased to a white heat the mass becomes grey at first, then assumes a greenish tint, which gets more and more distinct with a further increase of temperature. Up to this stage in the process of calcination the cement improves in quality, its density, firmness and capacity of hardening being increased. If the intensity of the heat still further augments, the greenish-grey color of the mass is changed into a bluish grey; and this is the stage when the cement begins to deteriorate. The mass gets more and more compact and resembles basalt. At last it enters a state of complete fusion, when it shows the appearance of obsidian, or vitreous lava. It is desirable to obtain a uniform pumice-like mass, of a greenish-grey color. Well mixed and well calcined cement ought to "stand," that is to say, it ought not to fall to pieces in cooling. This occurs, however, with burnt bluish-grey cement; and, also, with carefully calcined cement, when the chemical composition is not the right one. The more lime there is in the mixture the safer can the cement be calcined at a high heat without fear of its falling to pieces afterwards. Mixtures containing too much clay fall to pieces after the calcination. An addition of lime or alkali will prevent it, provided the cement is not burnt. The finer the condition and the more intimately the clay and the lime have been mixed, the higher can be the amount of lime used. But when the mechanical mixing has been done without accuracy and care, a greater amount of lime will only make things worse. It then does not prevent disintegration of the calcined mass, and adds, besides, another evil, causing it to become hot and to rise in contact with water. The utmost care in mixing can, therefore, not be enough recommended; for no good result can be obtained without it, whatever the proportions of the mixed substances may be. Whoever does not pay sufficient attention to this point, and attributes bad results to other causes, is inevitably led into errors and confusion.

The question, how much lime can be used, is answered by the formulæ I and II, given above, which indicate the limits. If on 10 equivalents of acids (including the sesquioxydes) less than 20 equivalents of lime are used, the cement will fall to pieces; if more than 24 equivalents of lime are used on 10 equivalents of acids, the cement will get hot with water and will not harden as a solid mass. The more lime a cement contains, within these limits, the slower it hardens, but the firmer and the more solid is the hardened mass, and the more valuable is the cement.

PROCESS OF HARDENING.

Well calcined Portland cement, when mixed with water so as to form a thick paste, becomes binding more or less rapidly, depending on its composition and on the heat to which it has been exposed. It solidifies and hardens in the air as well as under water. When hardening in the air, the cement does not lose any of the substances contained in it. When it hardens under water, a part of its soluble components, especially the silicates of alkali, are dissolved and extracted. The hardening process proceeds quicker at first in the air than in water, because carbonate of lime is then formed beside the silicate. But this takes place on the surface only, to a depth of about one-eighth of an inch. The interior mass remains free from carbonic acid and hardens equally fast in air or water.

Carbonic acid gas, though at first assisting the hardening process, effects afterwards a decomposition of the cements if they are loose or porous. Ground cement is rapidly decomposed by carbonic acid. The durability of the cement is, therefore, dependent on its solidity and density. The quantity of water that has to be mixed with the cement to prepare it for use, is about one-half the weight of the cement. This quantity is sufficient under ordinary circumstances. But in a high temperature, or when exposed to sun-heat for a long while, or when in contact with quite dry bricks, the cement may lose so much water that it cannot harden properly. It is not necessary to keep cement walls wet till the cement has hardened; but it is important to wet the bricks thoroughly before being laid in cement.

Hardened Portland cement, which is free from carbonic acid, contains 14 to 16 per cent of water. It is generally composed of:

1). Basic silicate of lime of the formula:

$$5\ Ca\ O.\ 3\ Si\ O^2 + 5\ H\ O.$$

2). Aluminate of lime (and the corresponding compound of sesqui-oxyde of iron with lime) of the formula:

$$3\ Ca\ O.\ Al^2\ O^3\ (Fe^2\ O^3) + 3\ H\ O.$$

3). Hydrate of lime. Ca O. H O. S.

Bessemer Royalties.—The statement circulated here, that they have been, or will this year be reduced, on products for either home or foreign consumption, is officially denied by Mr. Bessemer.

BURNING COAL DUST.

From "Engineering."

Those who have carefully studied the ordinary methods of burning fuel in our steam boilers and furnaces are well aware of its numerous defects, and of the losses of heat attendant upon it. Thus, besides the losses from conduction and radiation, which will take place to a greater or lesser extent with any system of burning fuel, there are, under ordinary circumstances, the losses due to imperfect combustion, to unconsumed coal falling into the ashpit, and to the heat carried off by the waste gases escaping to the chimney, this latter loss being largely increased by the excess of air which it is found requisite to supply to the furnace beyond that required for chemical combustion alone. To avoid these losses, various plans have been devised, the most thoroughly successful in practice, as well as one of the most perfect in theory of those hitherto brought before the public, being Mr. C. W. Siemens' beautiful system of regenerative gas furnaces. As far as the results obtained are concerned, these furnaces have really left little or nothing to be desired; but they have the disadvantage of being of considerable first cost, and, therefore, although they have been very largely adopted, they have not come into such general use as their economical working would otherwise warrant.

Under these circumstances various attempts have naturally been made to approximate more or less closely to the economy of the regenerative gas furnace without at the same time involving so great an outlay for gas producers, regenerators, &c.; but—although several experimenters have obtained good results—until quite recently no plan which could be said to be a fair competitor of Mr. Siemens' system had, so far as we are aware, been brought forward. A few months ago, however, Mr. Thomas Russell Crampton commenced experimenting on methods of burning fuel in the form of powder, and the practical results which he has lately obtained are so striking that we are inclined to regard his system as one possessing very great importance from many points of view. And here we may remark that the plan of burning fuel in a powdered state is, in itself, not new. Both in this country and abroad—and particularly in America—many attempts have been made to burn coal in the form of dust or finely divided particles; but prior to Mr. Crampton's experiments these attempts met with but indifferent success. One great difficulty which troubled most of the experimenters was that the flues of the furnaces became clogged with dust, this dust consisting in a great measure of unconsumed fuel, and representing, therefore, so much waste, besides being a practical inconvenience which it was found impossible to avoid. Mr. Crampton, however, *has* avoided this inconvenience, and the arrangements he has employed to enable him to do this have at the same time enabled him to obtain other advantages, of which we shall speak in due course. In the first place, however, we must explain briefly the principles upon which Mr. Crampton's system is based—principles, we may remark, in which sound common sense occupies a conspicuous place.

If two jets, one of coal gas and one of atmospheric air, be introduced into a chamber side by side and a light applied, a long flame will, as everybody knows, be produced, the length of this flame increasing according as the pressure under which the jets of air and gas are delivered is increased. Even if the gas and air are mixed before being introduced in the chamber, and are delivered into the latter through a single jet, the flame will still be produced, the length, although less, being, as before, increased by an increase of the pressure under which the jet of mixed gas and air is delivered. Now the existence of this more or less elongated flame proves that the combustion of the gas, even when mixed with a supply of air, is far from being instantaneous, and that, in order that perfect combustion may be obtained, a certain time must be allowed to elapse before the mixed gases are brought into contact with the objects which would reduce their temperature below that at which chemical combination will take place. When the fuel is supplied in a solid instead of a gaseous form, a still longer time is necessary for the completion of the process of combustion, the larger the particles of fuel the longer being the time thus required.

It is a recognition of this fact, that *time* is required to complete combustion, that forms the basis of Mr. Crampton's system of buurning powdered fuel. Instead of projecting the coal dust into a chamber where the heat is to be utilized, he mixes it with the requisite supply of air, and delivers the mixture into a combustion chamber or flue of such length or provided with such baffling screens that time is afforded for the combustion to be completed, before the heated gases which are produced arrive at the point where the heat is utilized. The time requisite to attain this end may be obtained by forming the combustion chamber with a zigzag flue, or by placing across it perforated screens of brickwork, which will form baffles, and delay the current of gases. In any case, openings are provided for drawing off the slag, which is deposited in the combustion chamber.

Of course the smaller the particles in which the fuel is supplied the greater will be the surface exposed by them in proportion to their weight, and the shorter therefore will—as we have already stated—be the time required for their combustion. In other words, the finer the particles the more nearly will they approach in character to gaseous fuel, and therefore if it were not for certain commercial considerations it would be advisable to reduce the fuel to the finest particles possible. Although, however, coal may, by suitable mechanical contrivances, be readily reduced to a state of impalpable powder, such reduction would be expensive, and therefore from an economical point of view unadvisable. Mr. Crampton has given this matter careful consideration, and we believe that the conclusion he has come to is, that regarded from a commercial point of view, it is unadvisable to spend more than one shilling per ton on reducing the coal to powder; or, in other words, that the coal should be reduced to as small particles as is possible for this expenditure, but that the advantages to be gained by the use of finer particles would not compensate for the extra expense of producing them.

To reduce the coal to powder, Mr. Crampton proposes to use ordinary millstones having a blast of air passed between their grinding surfaces, this blast both keeping the stones cool and carrying off the fine particles as soon as they are produced. The coal may, of course, if desired, be crushed between rollers, or by other means, before being fed to the millstones. The methods of delivering the mixture of powdered fuel and air into the combustion chamber, employed by Mr. Crampton, vary somewhat according to circumstances; the plan, however, which appears to be most generally applicable is that in which the powdered fuel is delivered from a hopper by means of a feed-roller into a coned pipe or nozzle, within which is a smaller nozzle discharging air under pressure. A kind of injector is thus formed which delivers the mixed air and powdered fuel into the main pipe leading to the combustion chamber, this pipe being traversed by a current of air under a low pressure. In this arrangement the feed-roller can receive its motion from a little engine directly attached to it, this engine being driven by the compressed air supplied to the injector nozzle. Where the furnaces are distributed about the works, the employment of little independent engines in this way will be a great convenience, and will save the erection of shafting.

We have said that the experiments already made by Mr. Crampton on his system have given most satisfactory results, and we hope to be able in an early number to lay the full details of these results before our readers. In the meantime, however, we may point out some of the advantages which Mr. Crampton's system appears to us to possess. In the first place, besides enabling ordinary good small coal or slack to be efficiently consumed, it affords great facilities for burning coal of inferior qualities. Take, for instance, coal containing a large proportion of sulphur. In order that such coal may be utilized for metallurgical operations in ordinary furnaces, it is requisite that after being powdered and subjected to a washing process, it should be moulded by pressure, &c., into blocks, while by burning it in the powdered state all the moulding process would be dispensed with. In cases when the coal merely contains an admixture of earthy matters, unaccompanied by deleterious volatile ingredients, the advantages in favor of Mr. Crampton's system are still greater. In such cases it is not even requisite that the coal should be washed, it being merely necessary to reduce it to powder, the presence of the earthy matters merely increasing the quantity of slag deposited in the combustion chamber without interfering with the perfection of the combustion. In dealing with the poor coals of India and similar fuel this would be an important consideration. Another advantage consists in the saving of labor effected, the supply of the powdered fuel to the furnace being regulated merely by opening or closing a valve, while there is the further advantage that the supply of air needed is little if any greater than that required for chemical combination, so that the intensity of the heat attainable is far greater than in an ordinary furnace where there is necessarily a surplus of air present. As a result, moreover, of the nicety with which the supply of air can be adjusted, the formation of smoke can, as the trials have shown, be completely avoided. Again, the system offers great facilities for utilizing the heat which would otherwise be carried off by the waste gases, it being merely necessary to pass these gases through regenerators arranged on Mr. Siemens' plan, and employ these regenerators to heat the air which is mixed with the coal dust in the first instance. In reheating and other similar furnaces, also, the fact of a slight pressure being maintained within the furnace is an undoubted advantage, as it prevents the indraught of cold air through crevices, or when the furnace doors are opened. Altogether, we consider that Mr. Crampton's system of burning powdered coal fuel is one which is well worthy the attention of all interested in the economy of fuel, and we anticipate that it will come into extensive use. We shall have more to say about the system in a future number, when we shall be at liberty to publish details of the trials, which have already been made on a practical scale.

CULVERTS UNDER RIVERS AND CANALS.

From the "Mechanics' Magazine."

There is always more or less hazard and risk in disturbing what may be called the "existing state of things." Nevertheless, it becomes imperatively necessary, on certain occasions, to incur the risk of so doing. Of all the examples of engineering practice, in which a corroboration of this statement is to be found, that relating to interfering with the *status quo* of the beds and banks of rivers and canals, affords the most conclusive one. Numerous have been the accidents, and dire the consequences of excavating even in the approximate locality of these situations. It is impossible to observe too much caution in conducting operations of this nature, which have now become more frequent than formerly. This is partly owing to the fact that rivers are no longer regarded as inseparable barriers between their opposite shores, and that attention has, during the last few years, been prominently drawn to the practicability of effecting a communication underneath instead of overhead. This has been exemplified on a gigantic scale by the proposed submarine communication between England and France, and is being practically carried out by the Waterloo and Whitehall Pneumatic Company, and by the construction of the subway under the Thames at the Tower. Although not arrived at this pitch of subfluvial tunneling, the French have accomplished something in that line, by the large syphon tube recently successfully laid under the Seine, to connect the sewage channels on each side of that river. The laying of culverts and pipes under embankments has always been a source of anxiety and trouble to the engineer, even when the embankments are made at the same time. It is needless to point out how greatly the trouble increases, and how much greater need there is of precautionary measures, when the case involves the undermining of a bank already *in situ*.

There are two very prominent instances to be adduced where the laying of pipes and culverts underneath the banks of water reservoirs were attended with leakage and bursting. The one is the well known catastrophe at Bradfield, some few years ago. The other is the leakage and subsequent emptying of the Vartry reservoir, constituting a portion of the Dublin Water Works. Whatever might have been the true cause of the former mishap, whether it was due to an error in the principle of construction adopted, or in practical working defects, there is very little doubt about the latter. The extrados of the arch of the culvert was left nearly smooth, without any offsets, steps, or "racking back," to afford a firm hold of the puddle of the bank. In fact, there was really a straight joint between the puddle and the masonry, whereas there should have been a union as intimate as it was possible for ingenuity to imagine. As might be expected, the water found out the "weak spot." The result was the emptying of the reservoir, which had taken months to fill, and the plunging of the Dublin Corporation into litigation, which entailed upon it a large amount of expense. In many of the towns where new sewage works are in course of construction, it has been necessary to lay iron pipes below the beds of the adjoining rivers and canals, both for the purpose of effecting a communication between the sewers upon the opposite sides, and also, in some instances, to constitute a channel of conveyance for the sewage to the fields intended to be irrigated. This subaqueous plan has been adopted at Norwich, where very extensive drainage and sewage works are in progress. Some idea of their extent may be gained from the fact that they are estimated to cost £60,000. Provided the foundation be good, and concrete be used liberally, the only point presenting much difficulty is the joints, which sometimes give a great deal of trouble. The depth to which the drains must be sunk depend, in the first place, upon the levels; and, secondly, upon the condition of traffic in which the river is placed. If the river be navigable, and used for the purposes of navigation, the pipes should not be placed too near the surface, and should be well protected, especially about the joints, with cement concrete, or they are liable to be damaged by the anchors of boats. Were there any choice in the matter, it would always be preferable to take the drain or pipe over instead of under the river, but it is seldom that the levels are so entirely optional as to afford the right of selection.

An instance of the bursting of a canal embankment, in consequence of excavating underneath it, for the purpose of constructing a culvert, occurred a very short time ago. A portion of the embankment of the Napton and Warwick Canal was washed away, making a breach nearly 40 ft. in width.

As a rule, we should prefer in these hazardous situations to lay cast-iron pipes instead of building a culvert. The time which the disturbance and interference with the existing bank occupies is of equal importance with the nature of the operations carried on. A much shorter time will suffice to lay in a pipe than to construct a culvert of brickwork or masonry. The former will also require less excavation than the latter, for supposing them to have the same internal dimensions, the arch, invert, and side walls of the culvert, will necessitate the taking out of considerable additional quantity of earth. These proportions in a cast-iron pipe are simply its thickness, which practically is inappreciable. Besides, an increase in the capacity or internal size of the pipe, produces little or no corresponding difference in the thickness. With the exception of the difficulty sometimes experienced in making good the joints, there is no comparison with respect to the relative facilities of the two methods for establishing a speedy and secure communication between the opposite banks. The manner in which the canal is constructed, at the place where the intended pipe or culvert is to cross, has a very great effect upon the risk attending its successful laying. Should the canal be carried altogether in an embankment, and the levels not permit of the pipe being laid in the natural ground, but require it to be placed in the artificial bank, the danger is seriously augmented. Not only is the foundation more treacherous and insecure, but the earth above is more liable to subside than if it consisted of a thin stratum of the natural surface. Subsidence is not necessarily a forerunner of leakage or bursting, but it frequently does precede these serious contingencies, and may be regarded as a warning sign which should never be disregarded. A distinction must be drawn here between the ordinary subsidence, which invariably follows the erection of every new bank, a short time after its construction, and that for which there is no apparent cause. The former is always expected, and provision made accordingly for raising the bank to its proper level. The latter should be at once carefully inquired into, and a constant watch set on the spot.

IRON AND STEEL NOTES.

Duration of Blasts.—A metallurgist who has spent the past winter in traveling among the French and English furnaces, gives it as his opinion that many of the recently-constructed and systematically managed establishments of the United States have nothing to fear from a comparison with the very best in Europe. In fact, there are some respects in which the ironmasters of this country are decidedly in advance of their trans-Atlantic compeers. The ever-increasing consciousness of the necessity of very high temperature in the blast is far more generally acknowledged and obeyed in this country than in Europe; and the average number of workmen required to perform the usual labor about the furnace is much greater there than here.

This observer gives the palm, among the works which he visited, to the furnace near Middleboro', in the Cleveland district. "Everything," says he, "is new, practical and neat, even to elegance."—Whether, however, in the colossal furnaces of that neighborhood the limits of economy have not been passed, is a serious question. The two furnaces at Rosedale are 103 feet high and 27 feet in the boshes. Certainly their production of eighty or ninety tons per twenty-four hours, great as it is, seems to be below the proportion of their vast dimensions.—Probably the use of the Lürman cinder-block, which has been adopted at some of the works, will be found especially advantageous in raising the product of very large furnaces, since it brings the slag discharged much nearer the center of heat, to say nothing of other favorable effects.

One point of difference between American and foreign blast furnaces is not in our favor. We are not able to keep as long in blast as do the Europeans. This complaint is quite general among us, and it is well worth while to inquire whether the difficulty arises from a defect in the quality of our natural or manufactured fire-proof material. With a view to answer this question, careful experiments have been made abroad upon samples of American clay and bricks furnished by W. M. Lyon, Esq., of Pittsburgh, and the results have just been communicated to us by Mr. George Asmers, under whose direction they were instituted.

It was found that our Mount Savage fire brick excels the best varieties in Scotland, Germany or Belgium, and that our Star at least equals them.—A third brand of cheap American brick, the Porter, showed itself not sufficiently fire-proof to be used even in the upper parts of blast-furnaces. These experiments do not by any means prove that there are not many other kinds of American fire-brick as good as those mentioned. In fact, we have ourselves obtained and manufactured material from New Jersey which successfully resisted tests before which the famous Stourbridge brick gave way.—The question to be answered in these experiments was merely whether it would pay to import Scotch or German brick on the assumption that all American material is defective. This question is now clearly answered in the negative; and if Mount Savage or Star bricks do not hold out as long as Garnkerk, the reasons must be sought elsewhere than in the raw material. Most complaints of this kind come from furnaces which smelt the very rich ores of Lake Superior, and that, too, with extremely small additions of lime. Under these circumstances, the formation of cinder at the expense of the alumina of the fire-brick is inevitable. The evil is aggravated when the blast is not so strong; as, for instance, at the charcoal furnaces of Lake Superior, when the pressure is but one and a half pounds. The zone of fusion here becomes annular, and hugs the walls, producing such a rapid action upon them that it is not surprising that the blasts in that neighborhood seldom last longer than twelve or fifteen months.

Careful experiments only can determine whether it would be wise to change the present proportion of flux and the pressure of blast to gain the advantage of longer campaigns. Such question cannot be flippantly answered *a priori*. One thing, however, is now certain. We do not need to look for better material in the construction of furnaces than our own country affords.

[The above is from the "Journal of Mining."—The "American Exchange and Review" makes the following comments :]

In addition to the above, it may be said that there is as singular a variation in the endurance of English furnaces as there is in furnaces in this country, in districts where the ores vary. We speak now in respect of the endurance of the furnace ring or inner walls. The gentleman last named is upon the line leading directly to the cause of difference between the endurance of American and of European furnaces. The peculiarity of ores demands a peculiarity in fluxing, and if that type or normal condition is not reached in the charge thrown into the furnace, the silex and alumina, not the alumina alone, must suffer, and the brick is dissolved or fluxed in itself. The nature of the ores reduced, therefore, has much to do in bringing about the difference in endurance. This may be considered a probable suggestion when we notice the large amount of lime in the charges of English furnaces as given in the type cinder of Dr. Percy, namely, 38 silex, 15 alumina, 47 lime; whereas in the large majority of our American furnaces 30 of lime would be the maximum.

Experiments at the Joint Expense of Ironmasters.—The Staffordshire correspondent of "The Engineer," says : Amongst some of the most advanced producers of pig and finished iron in this district, there has for some time been a desire that such a combination should exist that experimental works may be carried on at the cost of a joint purse and for the benefit of all, such as machine puddling, and other suggested improvements in the mill and forge department.

The same idea is now finding expression in respect of the making of pig iron. A South Staffordshire ironmaster, who within the last six years has made five visits to the Cleveland district, bases upon what is being done there an appeal to the trade in his district, to devise some machinery by which they may at one cost try each separate experiment, and to learn what would prove most valuable for permanent adoption. "During my first visit, I saw (he says) furnaces in advance of any then in Staffordshire ; since then, at some of the works, those furnaces have been altered once or twice, and are now either rebuilt, or are about to be." Indeed one of the Cleveland ironmasters himself remarked to me, in consequence of my having said that I had thought, the first time I was in the district, that the furnaces were so perfect they would probably remain for years unaltered : "In the last six years I have built five furnaces, each in advance of the other ; I have now pulled them all down and rebuilt, or am about to rebuild them as 85 ft. furnaces, with 27 ft. boshes, capable of making 450 tons of iron per week."

The South Staffordshire master remarks : "This seems a very lavish way of laying out money, but let us examine it more closely. To rebuild a furnace would probably cost somewhere about £1,000, but if by rebuilding you can save 1s. per ton on say 200 tons per week it would amount to £520 saved per year, or upwards of 50 per cent on the outlay." Now, as their furnaces make up to 450 tons per week, it is evident that they are wise to alter where they can see a saving of anything like 1s. per ton. What we want is a system of trying every new plan on one given furnace, and under the same circumstances, and in such a way as to obtain perfectly reliable data, such data to be open to all subscribers. This could be best done by forming a Blast-Furnace Institute, each member subscribing so much per furnace, according to the number of furnaces that he owned or leased. Such an institute would have a working committee, who would build or engage one or more furnaces, as well as a manager, and keep all accounts on the cost-book system, showing each separate account. The committee should meet at least once a month, and individually make frequent visits to the trial furnace. Say they are working a 50 ft. furnace, and at the first meeting agree to try the proper working height of furnaces with the different coals of the district. The furnace would be burthened to its very outside working powers at that height, with each of the coals to be tried, strict returns of the yields of everything being kept. These being finished, let the furnace be raised 5 ft., and then try them all again. Should any or all of them prove to work to better advantage at the increased height, then raise another 5 ft., and go on in the same way till that experiment was exhausted. We might then try increased heat of blast, or a close hearth, and then the yield of any one or all ironstones by themselves. The value of such an institute no one can tell, but supposing that by trying heights we saved as much as five cwt. of coal to the ton of iron—in Shropshire they save seven cwt., and in Cleveland upwards of ten cwt.—it would be somewhere near equal to adding one-seventh to the life of Staffordshire, whilst it would improve the quality also.

New Blast Engine. — A blast-furnace engine built at Norwalk, Conn., and described in the the "American Exchange and Review," has the following peculiarities: It is a vertical engine.—The air cylinder is 72-in. diameter and 8-feet stroke; the steam cylinder 36-in. diameter. The air piston and follower, instead of being cast iron and having packing between, consist of a ring six inches in thickness, with space for packing, which will be of solid wool felted and set out by a spring ring. Instead of the one piston rod taking the piston in the center, there will be three taking hold of the outside of the air piston, passing up through the head *outside of the steam cylinder*, and fastened to the crosshead. The great advantage of this is that it entirely prevents any steam or water from being carried down the piston rod through the stuffing box into the air cylinder. The air piston being simply a ring held by the three rods, and the entire center being covered with boiler iron slightly concaved, is very light. The steam piston is cushioned at both ends by passing and closing the exhaust ports just before the termination of the stroke, thus rendering striking the heads absolutely impossible, besides making the change of stroke almost instantaneous, and in consequence of this the variation of the blast is little or nothing.

The Large Blast-Furnace at Norton, England.—We have received, says the "American Exchange and Review," the following description of the blast-furnace at Norton, near Stockton-on-Tees, England, erected by John Player, of Player & Henderson, 30 Broadway, New York. It is 85 feet high, and 25 feet across the boshes; cubic contents 26,000 feet; and closed top, or bell and hopper arrangement for charging; has one horizontal blast engine, blowing cylinder seven feet diameter by seven feet stroke, working twenty-two revolutions per minute; has four of Player's patent hot-blast stoves, of thirty pipes each: heating the blast 1,000° to 1,200° Fahr., pressure of three and a half to four and a half pounds on the square inch, using six *tuyères*. It was blown in March, 1867, and in 1868 produced 25,327 tons of pig iron; and in February, 1869, was producing about 600 tons of foundry iron per week. The consumption of fuel is about one ton to the ton of pig iron. The ores are now 42 per cent, yielding two per cent better than with smaller furnaces. Less goes into the slag, or cinder, than formerly with the small furnaces. The fuel is ordinary coke that could not be worked in small furnaces, owing to its injurious effect on the quality of the iron.

The gas arrangements, or rather the arrangements for drawing it off, are so perfectly constructed that the supply is divided up into sixteen different jets, or flues, so that each stove and boiler has its supply independent of the other, and there is enough for steam and for heating the blast; it is regulated and consumed with the same facility that ordinary lighting gas is consumed in a dwelling, and is consumed on the principle embraced in an Argand burner, by a gas regulator.

The production of this furnace has exceeded the anticipations of the parties concerned by fully fifty per cent. It is illustrated in "Engineering" (August 10, 1866, p. 104), where it is stated that it was expected to produce 400 tons per week, while it now produces about 600 tons. It is expected that it will keep in blast five to six years longer, or seven to nine years in all. Owing to the time that it will probably remain in blast, the expenses of repairs will be less than in any other furnace, per ton of iron. There are no repairs to be charged to the hot-blast stoves, nor will there be, as, owing to the principles of their construction, none can be required. The labor account of this furnace is but a trifle in excess of that of one of eighteen feet, whilst the product is double.

Estimate of cost of this furnace at present wages and prices of materials, to include furnace, casting house, engine house, lift stoves, etc., complete to take the blast:

Foundations,	$5,300
Common bricklayers' work,	24,800
Fire bricklayers' work,	37,500
Cast-iron work,	25,000
Blast engine,	13,000
Boilers, etc.,	6,500
Pumps,	2,500
Machinery for hoisting,	3,500
Sheet-iron work,	4,000
Wrought-iron bands,	3,000
Valves, pipes, cocks, stays, etc.,	5,500
Various expenses, such as fitting, setting engines, boilers, scaffolding, extra labor,	15,000
	$145,600

We would modify this communication from Mr. Henderson by simply stating that we are under the impression that his estimates of cost of producing iron on the Lehigh are too low as to coal, limestone, and in some places in ore. The cost of limestone is about $1.75 in some places, of coal more than twice as much, even before the strike, and ore (brown hematite) is generally from $5 to $5.20 at the mines, to say nothing of the magnetic ore which forms nearly, and in some places quite, one-quarter of the charge, and is much more expensive. With what has been said in a previous article in the present number of the "Exchange and Review," our readers can draw their inferences as to the comparative excellence of small and large furnaces.

Mixing Iron Ores and Charges.—Dr. Crookes, in his new work upon iron, just received, has the following concerning the mixing of ores and charges:

1. Rich ores without earthy substances. They are mixed either with poor ores or with fluxes of blast-furnace slags, neutral silicates, etc.

2. Silicious ores. These are the most common; they are mixed with different fluxes, according to the state in which the silica is associated with the the ore, viz:

a. Silica is mechanically admixed with the ore, ores generally difficult to fuse, requiring aluminous and calcareous fluxes; best in the form of aluminous lime if suitable iron ores are not obtainable.—

Fluor spar has some advantages over common lime, as its fluorine volatilizes part of the silicon. It fuses easily with heavy spar, gypsum, and phosphate of lime, and is therefore a good flux for ores containing those substances. Ores at the same time containing quartz in a finely disseminated state and protoxide of iron are difficult to smelt. The silicious ores without manganese produce gray or mottled iron.

b. The silica is more or less saturated by other bases than iron. The silica is sometimes saturated with bases in such a manner as forms a suitable slag without the addition of other fluxes; or when contained in richer ores, an addition of neutral fluxes is required only to produce the sufficient quantity of slag. In most cases, however, the silica is not sufficiently saturated, and it then requires an addition of basic minerals, calcareous ores, or lime. In rare cases ores are smelted containing silicates so basic as to require an addition of silica or aluminous marl, etc.

c. The silica is combined with peroxide or protoxide of iron, as in puddling, refinery slags, etc.—These substances are difficult to smelt, and the best method is Lang & Frey's, according to which 25 parts of well burned fresh lime are slaked, and mixed while warm with 65 parts of pulverized slag and 10 parts of pulverized coal. The mixture is molded into forms, dried, and broken up to the size usual for smelting.

3. Calcareous iron ores being very refractory when smelted by themselves, are mixed with argillaceous iron ores or clayey substances. Pure quartz is seldom employed as an addition, for it requires a longer time for the formation of silicates, and is liable to scorify protoxide of iron.

4. Iron ores containing magnesia are very refractory, and require an addition of argillaceous substances and lime. If these ores contain at the same time a certain amount of manganese, the reaction of the magnesia will be partly neutralized.

5. Manganiferous iron ores sometimes smelt by themselves and are inclined to yield white pig iron, but they usually require an addition of lime in order to produce a slag free from iron. An increased addition of lime or magnesiferous substances is required if the production of gray iron is intended from these easily-fusible ores. Easily-fusible ores poor in manganese, such as some sorts of black-band, also require a greater addition of calcareous fluxes.

6. Titaniferous iron ores, usually difficult to fuse, require fluxes of lime and quartz. Alkaline fluxes are also very effective.

PLATING STEEL, ETC., WITH NICKEL.—There were recently exhibited before the Polytechnic Association of the American Institute, several specimens of iron and steel, upon which nickel had been deposited by the battery by a process devised by Dr. Isaac Adams, of Boston. It was claimed for this process, that while nickel is a much cheaper metal than silver, it is much harder, and is not affected by atmospheric influences, while at the same time the color is nearly equal to that of silver. Nickel is admirably adapted to the engraver's purposes, as from its extreme hardness, a plate of nickel will outwear several plates of copper. Hitherto it has been found impossible to deposit nickel to a greater thickness than that of a mere film. The mere deposition of nickel on steel is nothing new. Directions for the process will be found in Smee's work, published many years ago. But thus far it has been found impossible to deposit nickel in thick plates, for as soon as a film has been thrown down, the nickel is deposited in the form known as the "black deposit," which is friable and worthless.—Hitherto it has been thought necessary to use pure nickel for the pole or anode that is to be dissolved, but Dr. Adams has succeeded, even when the metal employed did not contain more than 75 per cent of nickel. Mr. Smith did not describe the process employed, as he stated that he was afraid his memory was not to be trusted in regard to it. The solution employed is the double sulphate of nickel and ammonia, but it must be prepared in a special manner, in order to insure success.

THE CLOSED HEARTH IN BLAST-FURNACES.—The correspondence of the "Engineer" thus mentions the use of this improvement in Cleveland:—The devices of the Cleveland iron-masters to stop all leakages or droppings, and to husband and economize all available products, are notorious. Nor are the other districts, so far as it is possible in the localities of old date, supine. The closed hearth system of working blast-furnaces, which has been applied to some forty furnaces in Prussia, is now being tried, we see, in Shropshire. By this system the hearth is kept much hotter than by the usual method, for there is no waste of heat to keep up the temperature in the useless channel between the hearth and the dam. Instead of blowing into the cinder, as in most of the English furnaces, the *tuyères*, upon Lürman's patent, are inserted on a level of about nine inches above the scoria outlet, thus bringing the full force of the blast upon the materials. Fuel is saved, and more iron, and of a better quality, is produced. The casting may be carried on without the blast being taken off, which is another source of economy, and the "blowing through" process after every cast, with its consequent waste of heat, is unnecessary. There is reason to conclude that the furnaces will not display a tendency to "bridge up," that condition of things being prevented by the intense heat, by which everything becomes thoroughly melted. So far as the experiments have already gone, the patent can be applied where tender as well as strong fuel is used.

THE SIEMENS-MARTIN PROCESS IN ENGLAND.—The North Yorkshire Steel and Iron Company, amongst whom Mr. Bernard Samuelson, the member for Banbury, is a conspicuous proprietor, have attempted to carry out the Siemens (Martin's) process for the manufacture of steel; but after much experimenting have, in reference, certainly, to some of the stages, abandoned the project, to the consequent great regret not alone of themselves, but likewise of the people of Newport, where numerous work-people began to find employment in a new avocation, but are now being discharged. The attempt is not, however, to be definitely given up. —*Cor. Engineer.*

NEW HEATON PATENT.—The invention of Mr. John Heaton, of Langley Mills, Derby, just specified, relates to improvements in the manufacture and production of iron and steel, and consists in the employment of the cinder or slag resulting from the balling of steel or of steely iron which has been obtained by the action of nitrate of soda or of nitrate of potash upon cast-iron, either in a converting vessel or apparatus such as is described in the specifications of letters patent granted to him (Nos. 798 and 1,295), or in any other suitable furnace or apparatus. This cinder or slag he employs either in what is known as the puddling process for the production of malleable iron, or of steel from cast-iron, or in the blast-furnace, for the purpose of improving the quality of cast or pig iron to be produced. In the employment of the product obtained by heating together oxide of iron and carbonate of soda, er caustic soda, or mixtures of the same for the production of malleable iron or steel from cast-iron, in what is known as the puddling process, and also its employment in the blast-furnace, for the purpose of improving the quality of cast or pig-iron to be produced.

PUNCHED STEEL AND IRON TUBES.—It is upwards of two years since we first publicly drew attention to the interesting process of making tubes by punching a solid ingot, and gradually enlarging it afterwards by punches of successively increasing diameter, so as to put the work upon the tube from the inside instead of, as heretofore, longitudinally. Messrs. Deaken & Johnson's punched tubes have since achieved a great commercial success. Upwards of a quarter of a millton have been made, and in many large contracts abroad, especially for the Remington rifles, no others are used.—*Engineering.*

TESTING MACHINE.—A writer in "Engineering," remarks that in some tests which he witnessed with the Kirkaldy machine, a trammel used on the bar itself, showed a far less amount of extension under various strains, than was indicated by elaborate machinery and index attached to the instrument for this purpose. This is an important point to have in view in connection with such tests.

THE pig-iron product of Great Britain in 1868 was 4,800,000 tons, that of the United States 1,603,000 tons.

ORDNANCE AND NAVAL NOTES.

EUROPEAN SMALL ARMS.—With regard to small arms, the most prominent feature of the year has been a continuation of the activity to which the events of 1866 gave the first impulse. In the North German army, the work of arming the troops with the well-tried needle-gun was pushed vigorously forward. For the fortresses, rifled percussion-guns of home and foreign construction (Austrian, &c., taken in war) were transformed into breech-loaders. It is proved, by the result of trials made at the military practice school in Spandau, with guns of the most approved systems, that the needle-gun, in precision and rapidity of fire, is inferior to none. On the other hand, the superiority of the small caliber, under some circumstances, is a matter that merits serious consideration. Hesse, Baden and Wurtemberg have armed their contingents with the needle-gun. Bavaria will not remain satisfied with the Podewils gun transformed on Lindner's system, and will probably adopt that of Werder. Austria has not yet completed the transformation of her old rifles according to the system of Wanzl. The model of Werndl presented some difficulties of construction, but the manufacture is now said to be going orwards. Here, as everywhere, it is the metal cartridge that has caused the trouble. Since April, the French infantry have been armed with Chassepots; but this is only the case with the army on its peace footing. Although private industry abroad and at home has been had in requisition, a sufficient number of these arms has not been procured for the army when in war, not to mention the reserves. Liège supplied 40,000 last year, and hopes to finish 80,000 in 1869. In spite of some defects, which the Minister of War himself acknowledges, the weapon seems, on the whole, to give satisfaction.

For the National Guard, the old rifles are being altered according to Snider. Italy and Russia have adopted the needle-gun. The Italian rifle pretty closely resembles the Dorsch and Baumgarten construction. In Russia the change progresses very slowly, and the breech-loaders, altered after the model of Carlé, are, according to the latest news, only in the hands of the guard. Berdan is contemplated as a new model, and of these 50,000 are said to be in readiness. Only the North German Confederation, with Baden and Wurtemburg, is at present completely supplied with breech-loaders, and then come France aud England. All the other States are more or less behindhand in this respect. At present the needle-system preponderates, as four great States and several of the smaller have adopted it.—*Kreutz Zeitung.*

THE MONITOR SYSTEM GAINING GROUND.—A British captain recently said: "For nineteen years we had to deal with vessels which we knew were worthless to fight in. They were gorgeous in appearance, rich in tradition, associated in the past with all our naval glories, and it is a bitter thing to part with them; but, still, that old wooden fleet has been at last got rid of, for last night the First Lord of the Admiralty promised you that even your reserve in future should be an irou-clad fleet. Having got rid of that wooden fleet you have now to prepare yourselves in the next ten years, if you are governed and led as you should be, to find the fleet trusting to steam machinery alone for its progress."

Whereupon the "Army and Navy Gazette" remarks: "Until Americans and French, Prussians and Russians decide upon ceasing to build iron-clads, casting and building up 20-ton guns, rifling and smooth-boring and manufacturing other implements for the ready and wholesale destruction of human life, we cannot afford to be behindhand; and so we fear the ugly, low, iron floating citadels must drive from the face of the waters the stately three-decker. War is a business, sad as it may be, and those who engage in it cannot indulge in a sentiment which might lead to bankruptcy. We must make up our minds to fight when called upon behind twelve or fifteen inches of iron armor-plates, and our movements regulated by steam power representing the combined strength of nine or ten thousand horses."

When the British navy comes down from three-deckers to "ugly, low citadels," protected by twelve or fifteen inches of iron," and propelled by "steam machinery alone," it will be a splendid realization of the *American idea*, first proposed by Stevens and made practical by Ericsson.

COMPARATIVE EFFICIENCY OF THE NEW BRITISH GUN.—A 9-in. Frazer gun, made for an endurance trial—a trial *à l'outrance*—has withstood upwards of 1,100 discharges, and of these 400 were full service rounds of 30 lbs., with 250 lbs. rifled shot, while the remainder were battering charges of 43 lbs., with the same shot. The gun is scarcely enlarged in the chamber, the rifling hardly worn.—It is a reason for just national pride, or, rather, for an even greater pride. No Krupp gun of large bore could be adopted with confidence in our naval service. No French gun could hold its own for an hour against such a test. As for the American guns—the huge smooth bores—they have been officially condemned and abandoned by the ordnance engineers of the cousin country.—*Engineering.*

We are greatly indebted to cousin Bull for working out the Fraser gun—at a fabulous cost. When it is quite perfected we shall adopt it in places to which it is suited. Meanwhile we are equally thankful to cousin Bull for disbelieving in the Rodman XV inch. It answers very well our modest requirements—such as enduring the thousand test rounds, firing hundred pound charges, and smashing such targets as it has been aimed at. The late Congressional ordnance committee, referred to by our cotemporary as the "ordnance engineers" of America, have, indeed, abandoned the Rodman, but as long as it is retained and believed in by the army and navy it will meet our wants till the Fraser and the Woolwich machinery are so far perfected that they can be safely copied.

French Merchant Marine.—The following results relating to the mercantile marine of France are taken from the general table of the foreign commerce of France just published by the Minister of Agriculture, Commerce, etc. On the 31st December, 1867, the total tonnage was 1,042,751, and at present is 1,048,679, showing an increase of 5,,928 tons. The number of vessels is 15,602. Of these, 7,212 are below 10 tons ; 4,757 from 10 to 100 ; 2,733 from 100 to 300 ; whilst above 800 there are only 76. Out of that total 215 are steamers representing 86,102 tons, an augmentation being found over the previous year of 8 ships and 11,192 tons. These figures are of great interest, as they show the constant advance of constructions intended to accelerate navigation. The port of Marseilles has the largest share—viz., 172,829 tons distributed amongst 792 vessels. Havre comes next with 132,296 and 390 ; Bordeaux, 129,167 and 413 ; Nantes, 114,734 and 647. Bordeaux has the greatest number of large vessels—283, from 100 to 800 tons. The difference between the entry and departure in ballast is considerable. In 1867 the tonnage was 19,000 for the former and 2,505,000 for the latter. The figures for loaded vessels are 6,366,000 and 4,125,000 respectively. The result is that France has always great difficulty in finding export freights.—*Army and Navy Gazette.*

Construction of Armor Plate.—Two armor plates, each 5 in. thick, manufactured by Cammell & Co., for the Austrian government, were recently tested by four shots from the 8-in. smooth bore at 30 ft. range. The one plate was made in the ordinary way, the other was made up of three thicknesses, by placing an armor plate $4\frac{1}{2}$ in. thick between two thinner plates, and rolling them down to the required thickness of 5 in. It was remarkable to see how closely the one plate resembled the other after the tests had been made, the greatest indents being 2.5 in. and 2.4 in. respectively, while the bulge in the back in both instances were $3\frac{3}{8}$ in. over an area of 2 ft. 3 in. and 2 ft. 4 in. respectively. It was clearly established that there was practically no difference in the merits of either plate. and both will receive a high classification.

The above is from an engineering and metallurgical journal of high authority, which fact prompts us to ask if all rolled armor plates are not made from piles of thinner plates, rolled down to the required thickness. We should think a difference rather than a resemblance in the results mentioned —the iron being the same—would have been remarkable.

The Russian Fleet.—The following are the particulars of the Russian fleet, as given in the "Journal of St. Petersburgh," from the report of the Ministry of the Marine : On the 1st of January, 1869, the fleet counted 230 steamers and 37 sailing vessels. The former consisted of the following armor-plated vessels : 4 frigates, 3 batteries and 13 monitors. Non-plated vessels : 6 ships of the line, 8 frigates, 18 corvettes, 7 clippers, 62 gunboats, 6 vessels colled "vapeurs-frigates," 4 imperial yachts, 13 schooners, 22 transports, 48 despatch boats, and 16 chaloupes. The sailing vessels consisted of 5 yachts, 4 schooners, 15 transports and 13 chaloupes. Of these 156 vessels were in the Baltic, 1 in the White Sea, 30 in the Caspian, 41 in the Black Sea, 31 on the eastern coasts of Siberia, and 22 in the sea of Ural. There were, in addition, 4 plated frigates and a steam yacht on the stocks in the Baltic, and 2 gunboats on the Siberian coast.

Bridge Building in War Time.—Bridge building was one of the arts brought to the greatest state of perfection during the rebellion. General McCallum states that the Rappahannock River bridge, 625 feet long and 35 feet high, was rebuilt in nineteen working hours; Potomac Creek bridge, 414 feet long and 82 feet high, in forty working hours; Chattahoochee bridge, 780 feet long and 92 feet high, in four and a half days; that between Tunnel Hill and Resaca, 25 miles of permanent way, and 230 feet of bridges, were constructed in seven and a half days; and near Big Shanty, $35\frac{1}{2}$ miles of permanent way, and 455 feet of bridges, in thirteen days.

Trial of English and French Rifles.—The current number of the "Proceedings of the Royal Artillery Institution" contains an interesting account of a trial lately, at Woolwich, of the Chassepot rifle in comparison with the Henry-Martini. As regards accuracy, it appears that the Chassepot was greatly inferior to the English arm. The worst target made with the Henry-Martini at 500 yards was 1.652 ft., the best with the Chassepot was 2.38 ft. The best target with the Henry-Martini showed a still higher degree of accuracy. viz: .96 ft. The trajectory of the Henry-Martini was flatter than that of the Chassepot, viz., 8 ft. 2 in. against 10 ft. In simplicity of manipulation the English rifle was superior, and it is less fatiguing to use. In firing for rapidity the Chassepot gave 20 rounds in 1 min 42 sec.; the Henry-Martini 20 rounds in 48 sec., or more than twice the rapidity.

New Turkish Iron-Clad —The Moyini-Zaffer, built for the Turkish government by Messrs. Samuda Brothers, at Poplar, was recently launched. The length is 230 ft., breadth 35 ft., depth 27 ft. Her burden is 1,400 tons, and her displacement 2,400 tons. Her armament will be four 12-

ton rifled guns placed in a double central battery, so arranged that they can all be fired on one broadside, or can be trained to fire in a line nearly parallel with the ship's course as bow and stern chasers. She is designed by Mr. Markrow, of the Thames Iron Shipbuilding Company, and will, if the expectatiou of her designer and builders be accomplished, be the fastest vessel of her class afloat.

NEW BOOKS.

Iron and Steel Manufacture: a series of Papers on the Manufacture and Properties of Iron and Steel; with Reports on Iron and Steel in the Paris Exhibition of 1867; Reviews of the State and Progress of the Manufacture during the Years 1867 and 1868; and Descriptions of many of the Principal Iron and Steel Works in Great Britain, the Continent of Europe, and the United States. By Ferdinand Kohn, C. E. New York: Virtue & Yorston, No. 12 Dey street; and D. Van Nostrand.

This handsome volume, which is profusely illustrated, embraces a series of paper on the manufacture of iron and steel; reports on iron and steel in the late Paris Exhibition; reviews of the state and progress of the iron and steel manufacture in 1867 and 1868; together with detailed descriptions of the principal iron and steel works iu Great Britain and on the Continent. . . . The author commences with a general notice of the iron aad steel manufacture in 1867, and in this the method of arrangement adopted in the body of the work is indicated. The first important division is devoted to iron smelting. This introduces much useful information about the Scotch iron field, particularly of the Gartsherrie, Coltness, Govan, and Langloan iron works. Barrow-in-Furness naturally comes in a prominent place, and the extensive works at Wigan are also described. The new district of Cleveland receives, as might be expected, an elaborate notice, the more modern furnaces being fully explained by illustrations. About one-half of this division is appropriated to continental iron works, and to various metallurgical subjects connected with the manufacture of pig iron. The engineering appliances required for blast furnaces—such as hoists, blowing engines, calcining stoves, &c.—come next in review, all the newest arrangements being fully described. A considerable space is devoted to cupolas, foundry cranes, and foundry work in general; the Phœnix Foundry, Glasgow, and the Ormesby Foundry, Middlesborough, being especially noticed. The production of Bessemer steel takes up a great part of the work. Very elaborate details are given of the plant required in carrying on the Bessemer process. Descriptions of the Cyclops Steel Works, Sheffield, of the Barrow, Dowlais, Don, Gorton, Mersey, and other steel works, appear with elaborate illustrations of the most improved arrangement of Bessemer plant. The Siemens-Martin process, now being successfully introduced in this country, is noticed; also half a dozen other processes for the manufacture of steel. The important regenerative furnaces of Mr. Siemens, which are calculated to effect a great economy in the amount of fuel required in heating and smelting furnaces, are naturally described in detail, more particularly as applied in several places to puddling purposes. Coming to the manufacture of wrought iron, we find articles on puddling, including the various attempts that have been made to carry on the process by mechanical means; followed by descriptions of forge hammers, forging presses, and rolling mills. In the latter department, tyre rolling, the universal mill, improved plate mill machinery and adjuncts, form a highly important feature in the volume. If we add that reports on the iron and steel exhibited at Paris, and on various matters connected with the strength and clasticity of iron and steel, are appended to those above enumerated, we have given a tolerably clear sketch of what Mr. Kohn has collected in this quarto volume of 288 pages, with its 83 full page illustrations. . . . The book will, assuredly, be of good service to the trade, particularly those who are practically connected with iron or steel works; and we have no doubt it will have an extensive circulation in all the iron-making districts. —*Iron and Coal Trades Review.*

The Mining Atlas. By Thomas Spargo, M. E., &c. Published by the author, at 224 and 225, Gresham House, Old Broad street, City. For sale by Van Nostrand, New York.

Mr. Spargo has in the present work excelled all his other publications, by the importance of the subjects and the exceedingly interesting manner in which they are treated. No fairy tale could contain a more romantic air, or be written in a more graceful style, than the "Mining Atlas." So varied is the geological, mineralogical, topographical, and geographical information and description that the work is a repertory of scientific information, associated with scenes and incidents, local and historical, of thrilling interest. All the maps and sections are beautifully executed, but that of Colorado territory is a surpassing beautiful specimen of orographical delineation. The literary portion of this number is varied and excellent. Chapter I is introductory and general; chapter II, how mines are worked, and plans and sections are framed; chapter III, general descriptions of the mining regions in Great Britain, of which maps and plans are given in the volume, such as Cornwall and Devon, Cardiganshire, and the Isle of Man; chapter IV, mineral-bearing regions of the American continent, Cardiganshire, Dolcoath Mine, and Botallack Mine. There are 36 quarto pages of literary description and original treatise on the important subjects above named. We strongly recommend not only persons engaged in mining as investors or otherwise, but the whole public to make the opportunity available of procuring what we do not hesitate to pronounce one of the most interesting works given to the public for many years.—*Mining Journal.*

Cyclopædic Science Simplified. By J. H. Pepper, Professor of Chemistry, F. C. S., A. I. C. E., &c. London: F. Warne & Co., Bedford street, Convent Garden. New York: Scribner, Walford & Co., 1869.

Professor Pepper is already known as a writer upon natural philosophy, but his earlier works were written for the youthful student. The volume now before us is an advance upou those, and conveys scientific information to such readers as may have neither the time nor the inclination to study the more recondite authors in such a form as is at once instructive and interesting. In fact, our author transports himself, with all his happy ideas and illustrations, from the lecture theatre to a volume containing nearly 700 pages of letterpress, interspersed with about 600 engravings. The subjects treated of embrace light, heat, electricity, magnetism, pneumatics, acoustics, and chemistry, which are considered in all their varied branches, their practical applications being illustrated. The various natural phenomena are explained with brevity and simplicity, and illustrations are given, by means of which the general reader is at once made familiar with facts and principles, which otherwise would be but "dark sayings" to him. The author introduces here and there portions of papers, by our veterans of science upon the subjects of which he treats. Thus, among others, we find the names of Faraday, Daniell, Wheatstone, Brewster, Tyndall, Crookes, Siemens, Noad, Spillar, &c., whose writings are judiciously quoted in their own words, and are not hashed into a jumble by the pen of a plagiarist. In this work the reader will find reproduced many of those interesting experiments illustrative of the peculiar properties of light, heat, and sound, with which Professor Pepper has been wont to entertain them. In short, as a first progressive book in natural philosophy, and as one eminently calculated to stimulate the reader to a deeper research into scientific truths, we know of none which commends itself so well as Professor Pepper's "Cyclopædic Science Simplified." It is, moreover, a handsomely got-up volume, and does credit to the publishers, who have made the outside of the work as attractive as the Professor has made the inside.—*Mechanics' Magazine*.

LINK AND VALVE MOTIONS. By WM. S. AUCHINCLOSS. New York, 23 Murray street. D. Van Nostrand. [Second notice.]

There are few draughtsmen who are willing to bestow much time on the perusal of books on valve motions, or to give attention to rules for their design. The feeling is well nigh universal that the proportions of the parts can be determined with greater confidence on the part of the designer and with at least equal speed by the usual process of laying out the motion on the drawing board, as by reference to any rules intended to supersede this labor. The work before us, so far as it relates to simple eccentric valve motions, differs from the ordinary run of works of this class in that it does not propose a series of rules liable to be forgotten or misunderstood, but simply shows how the labor usually expended in laying down a proposed motion may be dispensed with and the results arrived at in the absence of all drawing tools. This is done by simple measurement on an engraved diagram which the author has constructed, and which, from its simplicity and convenience, excites wonder that it has not been used before. By means of this the designer can, in less than a single minute, tell what proportions of valve and position of eccentric must be employed to give a desired point of cut off with any length of connecting rod; or can in like manner determine any of the features of the valve motion when the necessary data are given without recourse to any geometrical construction or the study of any rules. In laying out the link motion the conditions are more complex, and here it is necessary to resort to geometrical construction, but the author shows the effect of the different modifications that may be made so clearly that much of the difficulty which, to many, appears inevitably connected with the design of a successful motion of this class, is removed.

The work is plentifully supplied with such tables as are required in the operation of designing valve gear, the effort of the author throughout being to lessen the labor of the designer by performing for him all the preliminary and incidental calculations which arise in such work, leaving him simply to select what is applicable to the particular case in hand. We feel sure that all who read the work will be struck at once with its practical value. S.

THE SMOKE NUISANCE AND ITS REMEDY BY MEANS OF WATER, WITH REMARKS ON LIQUID FUEL. By C. J. RICHARDSON, Architect. Atchley & Co., Great Russell street, Bedford square, London. W. C. For sale by Van Nostrand.

Mr. Richardson's plan for remedying the smoke nuisance is by washing it with the spray of water. He gives it in detail, with diagrams; and he remarks that though it certainly is not possible to disturb the whole of the chimneys of London, the worst of them might be operated on, such as the chief kitchen flues of the great establishments which are continually sending out inky smoke. If it were possible, as he observes, to cut into all the chimneys of London and apply the remedy, the whole of the soot which at present escapes into the atmosphere might be caught and passed into the drains: it would there deodorize them, and the sewage would be rendered doubly valuable as manure, and be largely increased in quantity. This would certainly be the best mode of remedying not only the smoke nuisance, but the sewage emanations also, because so long as the air is contaminated with these, the smoke is at least useful in the air as a deodorizer of them, however injurious to human lungs in itself, or unsightly in its effects on buildings. In the pamphlet under notice, Mr. Richardson gives the results of his important experiments with liquid fuel. The substitution of petroleum for bulky coal in steamers would be an immense improvement, both in our mercantile and our naval shipping. Mr. Richardson says that "any boiler having water space below grate can be fitted to burn oil, so as to obtain a result from $2\frac{1}{2}$ to 3 times above that given by the best coal; 5 times, probably, of that given by common coal: no alteration will be required, only some additional plates in lieu of fire-bars."—*Builder*.

THE HANDBOOK OF IRON SHIPBUILDING. By THOMAS SMITH, M. I. N. A. London: E. & F. N. Spon. For sale by D. Van Nostrand, New York.

We have here a handy little manual, consisting of but sixty-two octavo pages, yet containing within that space a greater amount of useful practical information than is to be found in many works five or six times its size. Mr. Smith states in his preface that his book is intended to serve as a practical guide to shipowners, shipbuilders, inspectors, shipmasters, foremen, and intelligent working men; and it appears to us that it is well calculated to fulfill its end. It contains no elaborate theoretical disquisitions, and, in fact does not deal with theory at all; but contains abundant practical information as to the points to which attention should be paid in constructing an iron vessel. The book is divided into two parts, of which the first consists of practical instructions, while the second contains a variety of useful information, such as the weights of deck-beams, angle iron, plates and rivets, copper bolts, &c., the weight and strength of canvas, the allowances for waste in converting timber for shipbuilding purposes, and a large collection of detailed piecework and other labor prices.

The labor prices form an important feature in the work; they include the standard wages of the various classes of mechanics employed in a shipyard on the Thames, Mersey, Wear and Tyne, and the Clyde; and, as we have said, an extensive collection of the various piecework prices paid in the different districts. To these are added detailed tables of the actual costs for labor and materials of several iron steamers and sailing vessels of various sizes and classes.—*Engineering.*

Appleton's Cyclopædia of Drawing. Designed as a Text-Book for the Mechanic, Architect, Engineer, and Surveyor. Part I. Edited by W. E. Worthen, New York. D. Appleton & Co., 90, 92 and 94 Grand Street.

The system of publishing valuable books in parts by subscription has long found favor with mechanics aud others, and very properly so. The present work, when completed, iu thirty parts, at thirty cents each, will cost, including binding, not less than $10.50 to $12.00, a sum which few mechanics, especially apprentices, would care to iuvest in a single work. But by taking it in parts at thirty cents, many a quarter will be saved which would otherwise be spent for cigars or lager, while the money thus invested will bring in better returns than if it were placed at compound interest. Moreover each part may thus be studied carefully as it is received, and the money need not be invested in any part of the book until that part is wanted. Of course these remarks apply chiefly to our young men, or rather boys who are endeavoring to fit themselves for a future career of usefulness.

Of the character of the work it is hardly necessary to speak. We were familiar with the first edition and held it in very high esteem, and we have no doubt that the author has introduced into this new edition those improvements which a riper personal experience and the general advancement of the art have brought to his notice.—*Manufacturer and Builder.*

Force and Nature, Attraction and Repulsion; the Radical Principles of Energy, Discussed in their Relations to Physical and Morphological Developments. By Charles Frederick Winslow, M. D. Philadelphia: J. B. Lippincott & Co.

We have endeavored, before expressing our views in regard to this book, to read it in a perfectly candid spirit of inquiry. We confess that we found it hard to maintain that spirit to the end. Its style is at times forcible, and its author has evidently caught more than a mere glimpse of certain fundamental truths; but while saying this much, we are compelled to add that it is one of the most illogical books we ever attempted to peruse. It is full of fautastic speculations, and contains not a few errors in its statements of facts. It is wearisome, from its interminable repetitions and its diffuse method of discussion will hardly fail to draw upon it the severe criticism of thinking readers. In short, it is to philosophy what punch is to the palate, full of incongruities; and, although too much diluted by redundant forms of expression, till quite palatable, but not very nutritious. Claiming at the outset to assume nothing, it ends by assuming everything. Written to enunciate what is evidently a pet theory of the author, namely, that repulsion is equal in quantity to attraction, and that the two are co-existent, and the foundation of all material existence, it will convince few; while its speculations will, if we mistake not, draw upon its author a storm of adverse criticism.—*Scientific American.*

Iron: Its History, Properties and Processes of Manufacture. By William Fairbairn, C. E., F. R. S., &c. &c. Third edition, revised and enlarged. Edinburgh: Adam and Charles Black, 1869. For sale by D. Van Nostrand, N. Y.

When Mr. Fairbairn gave the pofession a second edition of his treatise ou iron and steel manufacture, he predicted that great changes would, at no great distance of time, occur in that department of industrial art, and which would result in the production of a superior article. These changes have, to a great extent, occurred, and have necessitated another edition of Mr. Fairbairn's most useful work, which now lies before us. The verification of this prediction has been chiefly accomplished by the extensiou of the Bessemer process, and the gradual introduction of the homogeneous system into the manufacture of metals. Mr. Fairbairn describes all the new improvements, including the Heaton process, which, by the introduction of the crude nitrate of soda, results in the production of "steel iron" from any kind of pig iron. This method of manufacture is described in a chapter which embodies the improvements in the manufacture of iron and steel from 1864 down to the preseut time. The work is fully illustrated, and contains some valuable information upon the properties of the materials of which it treats.—*Mechanic's Magazine.*

Examples of Modern Steam, Air and Gas Engines. By John Bourne, C. E. London: Longmans, Green, Reader and Dyer, Paternoster-row. For sale by D. Van Nostrand.

We have now got half way through Mr. Bourne's work on modern engines, Parts XI and XII being now to hand. In these, as in those which have preceded them, there is no lack of interest. After pointing out the probable course of improvement in locomotives, the author gives a condensed account or recapitulation of the principal classes of improvements in the steam engine, which have been propounded at various times in its history. These are arranged chronologically, dates and the numbers of patents—where patents have been obtained—being given. Thus, independently of the practical observations of the author, we have a very complete index of the subject, which, of itself, will prove of great value to many designers and improvers of steam engines. A large folding plate of Captain Ericsson's original "Monitor," showing the screw and turret machinery, accompanies Part XI, whilst Part XII has two plates, giving the details of surface-condensing engines, by Messrs. Richardsou.—*Mechanic's Magazine.*

The Industries of Scotland. By David Bremner. Edinburgh: Adam and Charles Black, 1869.

During the last year, a series of very interesting articles upon the industries of Scotland appeared in the weekly issue of the "Scotsman." These articles were fair and accurate accounts of the various branches of trade, and we are now glad to see them collected together and reproduced in a more permanent form The volume in question is a history of the rise, progress, and present condition of the Scottish industries, especially of those which, by their extent or peculiarity, merit notice. Mr. Bremner judiciously confines himself to a plain narrative of facts, which have been carefully selected, and are interspersed with here and there a few general reflections. Iron works, coal mines, shipbuilding establishments, railway works, linen and cotton works, fisheries, &c., present themselves in turn.—*Mechanic's Magazine.*

A Treatise on the Teeth of Wheels; demonstrating the best forms which can be giveu to them for purposes of Machinery, such as Mill-work and Clock-work; translated from the French of M. Camus, by John Isaac Hawkins. Third edition. Philadelphia: Henry Carey Baird, 406 Walnut street. Price $3.

The "rule of thumb" has always very extensively governed the construction of toothed gearing, and the consequence is that perfect gearing is very rare in machinery. It is astonishing when we consider the immense saving in friction, wear and cost of repairs, and the greater regularity of operation obtained by the use of gears with properly constructed teeth, that more attention has not been paid to the subject. This little book explains, in such manner as to be intelligible to those who are in the least acquainted with mathematical science, the proper form of the teeth of wheels, and the art of finding the number of teeth which ought to be given to wheels and pinions. It goes very fully into the subject, and is illustrated by eighteen plates of diagrams.—*American Artizan.*

Report of a Special Committee on the Merits of a Proposed Method of Supplying Pure Air to Schools, Churches, Hospitals, Asylums, Dwellings, and all Occupied Houses; also Railroad Cars and Passenger Vessels. Presented at the Regular Meeting of the New York Association for the Advancement of Science and Art, at Cooper Institute, and unanimously adopted, March 8th, 1869.

The pamphlet of which we have just given the title is a singular document—singular for its grammar, and perhaps still more singular from its strange mis-statements of scientific facts.

The "Manufacturer and Builder" thus commences a criticism of some length, and we think it makes out a rather embarrassing case for the unanimous New York Associatiou for the Advancement of Science and Art.

General Problems in the Linear Perspective of Form, Shadow and Reflection: or the Scenographic Projections of Descriptive Geometry. By S. Edward Warren, C. E., Professor of Descriptive Geometry. etc., in Rensselaer Polytechnic Institute. New York: John Wiley & Son, 2 Clinton Hall, Astor Place.

Professor Warren is widely and favorably known as the author of several valuable works on drawing. The present volume ample sustains his previous reputation and must prove not only a most efficient text-book in our industrial schools, but a valuable aid to architects, engineers, and all who have occasion to make accurate drawings.—*Manufacturer and Builder.*

The Millers', Millwrights' and Engineers' Guide. By Henry Pallett. Illustrated. Henry Carey Baird, Publisher, Philadelphia. Price $3 post-free.

This book should be in the hands of every miller. The subject is treated in a plain, familiar manner, free from all unnecessary technical words, and intelligible to those of the most limited education, the general information afforded being almost invaluable to those who have not had an opportunity of judging the best way of milling. The transparent model attached to the work showing the actiou of the furrows cutting wheat and the operation of the millstones is, of itself, worth the price of the book. It is, perhaps, as full and complete a work on milling as has ever been published, and ought to be read by all engaged in the business.—*Milling Journal.*

A Practical Course of Military Surveying; including the Principles of Topographical Drawing. By Capt. Lendy, F. G. S., etc. With an Atlas, mostly by Maj. Petley. New Edition. London: Atchley & Co. 1869. For sale by Van Nostrand.

That this able work has reached a second edition is a practical and well-merited testimony in its favor. The author is director of the Practical Military College at Sunbury; and Major Petley is Professor of Military Surveying at the Royal Military College, Sandhurst. This edition contains many additional plates, etc. The practical part of the work has not been altered, and remains quite elementary, though deemed sufficient for all field purposes. A brief sketch of the operations necessary for a trigonometrical survey has been added.—*Builder.*

Physical Survey of Virginia; her Geographical Position; its Commercial Advantages and National Importance. Preliminary Report by M. F. Maury, LL. D., etc., Professor of Physics, Virgiuia Military Institute, Lexington, Va. Second edition. New York: D. Van Nostrand, publisher, 23 Murray street and 27 Warren street.

This work, besides pointing out the advantages which arise from the geographical position of the magnificent State of Virginia, and which are illustrated by large maps, contains very valuable information as to its climate, soil, and productions, its mineral resources, water-power, and manufacturing facilities, and gives valuable suggestions as to how its industry may be stimulated, its enterprise encouraged, the material prosperity of its people advanced, and its general welfare promoted.—*American Artizan.*

The Parks, Promenades, and Gardens of Paris, Described and Considered in Relation to the Wants of Our own Cities and of Public and Private Gardens. By W. Robinson, F. L. S. London: John Murray.

This is a comprehensive and elegant work, profusely illustrated, and of undoubted value to public and private decorators of parks aud gardens.

Polar Magnetism: A Paper read before the American Institute on the Cause of Polar Magnetism, the Attraction of the Needle to the Pole, the Variations of the Compass, and the Phenomena Incident to the Same. By John A. Parker. New York: Wiley & Son.

Second Lecture on Polar Magnetism: Its Astronomical Origin; Its Period of Revolution and the Synodical Period of the Earth Identical. Read before the American Geographical and Statistical Society. By John A. Parker. New York: Wiley & Son.

These two pamphlets, instead of being a contribution to the stock of public knowledge, are simply an exhibition of the ignorance of the author concerning a subject which appears to have occupied his attention since he published a book of similar calibre, on the quadrature of the circle, some eighteen years ago. This says the reviewer, in the "American Journal of Mining," and he certainly makes out his case, in an article of some length and a good deal of breadth.

The Resources of Missouri, and the Natural Adaptation of St. Louis to Iron Manufacturers. By Sylvester Waterhouse, of Washington University.

This pamphlet, which was published originally in 1867, has recently been enlarged by an appendix on the adaptation of St. Louis to iron manufactures. It contains much that is interesting. The experiment in manufacturing iron at Carondelet affords the data for Professor Waterhouse's conclusions. In the first place, the quality of the pig iron made there is pronounced good by a number of presidents of companies engaged in manufacturing articles of hardware. As to the cost of manufacturing, the pamphlet goes into elaborate statistics and makes out a good case.

Kemlo's Watch-repairer's Hand-book; being a Complete Guide to the Young Beginner in Taking Apart, Putting Together, and Thoroughly Cleaning the English Lever and other Foreign Watches, and all American Watches. By F. Kemlo, Practical Watchmaker; with Illustrations. Boston: A. Williams & Co., 100 Washington street.

This little book should be owned and studied by every young watchmaker and watch-repairer; and it is of value to every owner of a watch, teaching him how to take care of his bosom friend.—*American Artizan.*

To which we may add that the little work is elegantly got up and illustrated, being, in fact, an art book as well as a text book.

French Measure and English Equivalents.—By John Brook. Sheffield.

In a series of compact tables the English values of French measure are arranged from one to a thousand millimeters, and from one to a hundred meters; the fractions of an inch progressing in sixteenths are also reduced to French values. The little book will be found useful to almost every engineer.

Roads, Railways, and Canals for India. By T. Login, Esq., C. E., &c. London: E. & F. N. Spon.

This is a double pamphlet, full of facts, calculations, and suggestions on this important matter, and will no doubt prove of value to all immediately interested in the development of the economic resources of India if not of America.

British Rainfall, 1868: On the Distribution of Rain over the British Isles during the year 1868; with Remarks and Illustrations. Compiled by G. J. Symons, F. M. S. London: Stanhope, 1869. For sale by Van Nostrand, New York.

MISCELLANEOUS.

Heat Necessary to Ignite Vapors.—W. R. Hutton, of Glasgow, has recently determined the degree of heat at which the vapors of a number of liquids catch fire from a burning candle, when it approached to the surface of the fluid at a distance of 1.5in. or 0.5in. The results of these experiments are recorded in the subjoined table:

	Specific weight.	Inflaming Point in Degs. of Fah. At a distance of 1.5in.	Inflaming Point in Degs. of Fah. At a distance of 0.5in.
	Deg.	Deg.	Deg.
Sulphuric ether	747	Below 53	....
Bisulphide of carbon	1.270	do 53	....
Petroleum benzine	706	do 53	....
Benzole from coal tar, 90 per ct.	861	do 74	71
Crude paraffin oil	849	do 74	72
Crude naphtha	884	do 78	74
Whisky	940	do	85
Wood naphtha	9.840	do 87.8	81
Crude paraffin oil	891	do 89	84.2
Crude naphtha	881	do 90	·86
Dutch gin	930	do	90
Wood spirit	827	do 96.8	84.2
Illuminating naphtha	859	do 100	91
Wine spirit	817	do 104	73
Whisky, 15 overproof	893	do 109	83
Whisky, 11 overproof	905	do 110	84.2
Kerosene	801	do 118	110
Light oil from coal tar	920	do 119	109
Spirit from resin	922	do 122	105.8
Turpentine	875	do 130	119
Sherry wine	993	do	130
Port wine	1.003	do	130
Refined paraffin oil	809	do 134	123
Refined paraffin oil	814	do 138.2	127
Fusel oil	850	do 140	129.2
Oil from resin	987	Above 212	....
Heavy tar oil	950	do 212	....

Street Washing and Sweeping.—The following practical remarks were made by Mr. J. K. Fisher before a recent meeting of the Polytechnic Association of the American Institute:

"The superiority of washing streets may be seen by those who observe the following facts:—1st, Fully a third of the dirt is left on the pavement by the machine and hand-brooms in Broadway. 2d, A strong shower washes the pavement clean, excepting where there are holes, in which water remains and sediment falls. 3d, In wet weather the streets are not swept, but mud accumulates for days and weeks; and the mud holds water like a sponge, and keeps the streets wet for days after the sidewalks would be dry, were the mud not tracked upon them. 4th, The best time to wash a street is while it is wet; the washing engine would then use less water. 5th, As soon as rain is over, the washing engines would do their work, and blow the dirty water out of the holes, and leave the pavement nearly dry, so that in half an hour it would be completely dry; thus saving the muddiness, which now lasts from two to six days before the contractor sweeps. 6th, The cost of washing by hose-jet in Sheffield was less than half the cost of sweeping and cartage; proper washing engines would further reduce the cost. The washing would make less dust than sweeping.

"Considering the mud avoided, and the little if any dust, the washing system would give more than double cleanliness, probably at half the cost of the present inefficient system. The washing engines would be efficient fire engines, and would always be ready to leave their street work instantly when fires occur; their cost would therefore be little beyond what is now incurred for engines and men, who do but few hours' work in a year.

"Floating fire-engines could dredge the docks by jet, while the tide runs outward, and thus clear the docks from the street dirt, and at the same time serve as fire engines better than if kept inactive, without steam up and their fires strong.

"Some of our sewer engineers say that the sewer gullies are not made to pass street dirt, but to catch it; and that, therefore, alterations would be required to make this proposed system practicable. Others say that much of the street dirt does go through the sewers. I am convinced, by evidence published in England, that the system is practicable with the present gullies, and that the gully traps are needed to catch the gravel that is often found in streets, and that might do harm in the sewers. Mr. McElroy's paper is good professional evidence against the hasty surmises of engineers who have not studied the subject."

Dates—Amendment in the British Constitution Needed.—According to English newspapers, technical, commercial and literary, no event ever took place on the 20th of July, or the 11th of December, or at any other period absolutely defined in the statement of fact. "Messrs. Samuda launched the ironclad *Vengeance* on Thursday;" "Mr. Scott Russell yesterday lectured the Royal Institution;" "the John Bull won the ocean race, by arriving on Friday;" "a total eclipse of the sun will take place on Wednesday." In rare instances we are favored with a hint in the shape of "next" or "last," but not by polite writers. The man who hopes to be a F. R. S. would utterly ruin his chances by writing "Wednesday last;" and there is not an engineer's apprentice in Great George street who dares write "Thursday July 1st," in an article intended for publication.

Nicholas Woods, the wonderfully versatile and remarkably accurate reporter for the "Times," who does with equal elegance an armor test at Shoeburyness one day and a marriage at St. George's, Hanover Square, the next; a hanging at Old Bailey in the morning and the trial of a surface condenser at the Isle of Dogs in the afternoon—Woods is a precedent and a pillar in the British Constitution. Woods says in the "Times" that a thing happened "on Thursday," and even Colburn does'nt quite like to add "July 1st," for, independent as he may be in his professional convictions and expressions, an un-Woodsy style of reporting a fact would be as inexcusable a violation of British precedent as traveling in cars that were not locked, or crossing the channel with the decency and comfort of Long Island Sound navigation.

Seriously, this almost universal omission of dates in the English papers is as unnecessary as it is inconvenient. One has to find the date of the paper and compute the time, unless, as is often the case in newspaper offices, one happens to be reading a slip without date; but when a technical weekly or monthly copies *verbatim* from a *daily* about the trial that was completed "yesterday," or the ship that was launched on "Thursday," this affectation of the cockney-daily style becomes ludicrous as well as embarrassing.

Subjects of British Letters Patent for 1868. Mr. George Shaw has drawn up a condensed analytical list of letters patent for inventions granted and provisional protections applied for during the year 1868. From this summary of inventive effort we subjoin an indication of the progress discernible in materials and appliances connected with building trades. In all, there were 3,991 applications. Of this large number 11 related to improvements or inventions connected with sewers, drains and cesspools; 13 with making and sweeping roads; 38 appertained to wheels for railway and other carriages; 4 to docks, breakwaters, and submerged works; 84 to furnaces and consuming fuel; 116 to railways, locomotives and railway carriages; 185 to steam engines and steam boilers; 33 to artificial fuel, matches and splints; 6 to baths; 4 to bells and bell-hanging; 2 to castors for furniture; 32 belonged to latches, hinges and springs for doors; 5 to fenders, fire-iron and fire-guards; 39 to nails, bolts, screw-nuts, and rivets and machinery for manufacturing the same; 21 related to the processes of sawing, planing, boring, etc., stone and slate; 54 to sawing, planing and turning metals, wood, etc.; 79 to telegraphs, signals and intercommunication in railway trains; 4 to surveying instruments; 14 to drawing, painting, and exhibiting pictures and photographs; 31 to windows, sashes, shutters, doors and fencing; 3 to floors and flooring machinery; 52 to tunnels, bridges, arches and portable and other buildings; 21 to lime, brick, and other kilns and coke ovens; 10 to artificial stone, plaster and cements; 30 to bricks, tiles and clay-pipes; 13 to glass manufacture; 19 to blinds, curtains and shades; 43 to stoves, grates, fire-places, kitchen ranges and culinary apparatus; 30 to warming and ventilating buildings; 11 to gas-burners; 33 to gas and water meters and regulators; 43 to cocks, taps and valves; 31 concerning pipes and tubes for steam, water and gas, and joints for the same; 21 related to water-closets and urinals; 16 to hydraulic machinery for raising and distributing water; 5 treated of the preservation and preparation of timber; and 2 apportioned to coffins, hearses, and preservation of the dead. Satisfactory as this amount of activity thus indicated may be, it appears trifling to that fermenting in men's brains on the other side of the Atlantic.—*Builder*.

The Guibal Fan.—A large fan, on the Guibal principal (see Van Nostrand's Magazine, No. 1, page 43), was recently started at the Byers Green Colliery, and did good work. It was run up to 60 revolutions per minute, and at this speed produced 68,000 cubic feet of air per minute, with a water gauge of 3.10 in. The quantity of air previously got by the furnace was 11,000 cubic feet below the quantity produced by the fan, or 57,000 cubic feet. The fan has not yet been worked up to its maximum power, as it is guaranteed by the maker to work up to seventy revolutions per minute. The makers are Messrs. Black, Hawthorn & Co.. of Gateshead.

LONG SPAN BRIDGES.—Prof. De Volson Wood has furnished the following interesting summary to the "Journal of the Franklin Institute:"

TABLE OF BRIDGES HAVING LONG SPANS.—*Trussed Bridges.*

NAME OF BRIDGE.	Total length in feet.	No. of spans.	Longest span.	REMARKS.
Schaffhausen, Switzerland	365	2	193	Weisbach Mech. vol. II, p. 283.
Trenton, N. J	880	5	200	Wooden arch trussed. Haupt on Bridge Construction, p. 242.
Columbia, Penn'a.............	5,280	29	200	Burr's; destroyed during rebel invasion, 1863. Mahan, p. 240.
Newark Dyke, Eng............	......	......	240½	Longest span of Warren's Girder. Jour. Frank. Inst., vol. 26, 3d series, p. 156.
Essex, Mass....................	250	1	250	Mahan, Civ. Eng., p. 238.
Chepstow, Eng.................	606	4	306	Queen Past—Theory of Bridges—Weak.
Noget, E. Prussia.............	374½	2	321	Jour. Frank. Inst., vol. 39, 3d ser. p. 230.
Upper Schuylkill..............	......	1	340⅓	Mahan, p. 237.
Louisville Bridge, over Ohio river,	5,201	25	370	Fink's Truss—Report of Committee.
Wettingen, Germany,...........	390	1	390	Erected in 1778. Longest span of wooden truss on record. Weisbach Mech. vol. II, p. 83.
Dirschau, Prussia	2,383½	6	397¼	Iron lattice. Jour. Frank. Inst. vol. 39, 3d series, p. 230.
Kuilmburg, Holland	......	......	515	Longest span trussed bridge. Official report, 1866.
Derry, designed by Claus (never built)......................	......	1	900	Proposed wooden structure. Weis. Mech. vol. II, p. 84.

Tubular Bridges.

NAME OF BRIDGE.	Total length in feet.	No. of spans.	Longest span.	REMARKS.
Conway, Eng..................	......	1	400	Civ. Eng. Jour., 1848.
Britannia, Eng.................	1,513	4	460	Tubular bridges by Dempsey. Traité de la Construction des Ponts Métalliques, pl. X.
Victoria, at Montreal, Canada....	10,284	25	330	Hunt's Merch. Mag., vol. XXXI, p. 504; 24 spans are each 242 feet.

Arched Bridges.

NAME OF BRIDGE.	Total length in feet.	No. of spans.	Longest span.	REMARKS.
Neuilly (over Seine)............	*640	5	128	Mahan, p. 225.
Teff, South Wales..............	. ....	1	140	Failed by rising of the crown. Woodbury on the arch, p. 432.
London Bridge.................	784	5	152	Woodbury, p. 432—for railr'd purposes.
Rica, Ayr.....................	......	......	180	Jour. Frank. Inst., vol. 39, p. 231.
Chester or Grosnover...........	......	.....	200	Mahan, p. 228.
Great Washington Aqueduct.....	......	......	200	Sc. Am. 1860, p. 86. Cast iron, by Rennie.
Southwark	......	......	250	Smile's Lives, Eng., vol. II, p. 188.
Trizzo Adda....................	251	1	251	Longest stone arch on record. Treatise on Bridges, Weale, vol. I, p. 48.
St. Louis Bridge...............	1,509	3	515	Not yet built. The arch to be of steel. Rep. by the Co., 1858.
Proposed bridge over the Thames, by Telford..........	......	1	600	To be made of iron. Weisbach, v. II, p. 86.

* More than 640.

Suspension Bridges.

Name of Bridge.	Total length in feet.	No. of spans.	Longest span.	Remarks.
Niagara Carriage Bridge	....	1	1,264	Sc. Am., vol. XX, p. 218. This bridge is about a mile below Niagara Falls.
Cornwall (proposed to be built across the Hudson river, 42 miles above N. Y. City)......	2,409	1	1,600	Jour. Frank. Inst., vol. LVII, p. 165.

Name of Bridge.	When built.	Span.	Remarks.
Douro, at Oporto	1842	558	Sup. to Weale's Bridges, p. 144.
Menai, Eng................................	1825	580	Chain cable. Mahan's Civ. Eng., p. 255
St. John's, N. B..........................	1852	622	Sc. Am., June 19th, 1862.
Nashville, over Cumberland..............	1850	656	Destroyed by rebel Gen. Floyd, Feb 1862. Sc. Am. Mar. 30th, 1850.
Pesth, over Danube	1849	670	Total length, 1250. Jour. Frank. Inst., vol. XVII, 3d series, p. 300.
Niagara Railroad Bridge.................	1854	822	Jour. Frank. Inst.
Fribourg, Switzerland...................	1834	870	Jour. Frank. Inst., vol. XXIII, 2d series, p. 141.
Lewiston (7 miles), below Niagara Falls ..	1856	1,043	Sc. Am., June 1st, 1861. Blown down Feb. 1864.
Lexington and Danville Railroad Bridge...	1856	1,220	Jour. Frank. Inst., vol. XXXIX, 3d series, p. 230.
East River Bridge, N. Y. City............	......	1,600	Proposed. Jour. Frank. Inst., vol. LXXXIV, p. 243.

Root's Pressure Blower.—This device is now, by general consent, here and in England, one of the best, if not the very best means of blowing cupola furnaces. A pair of reciprocating pistons afford, of course, a steady blast of any desired pressure; but they are costly to construct, and the piston packing and valves are subject to wear. No fan blower can be depended upon to give the requisite pressure, viz: half a pound to a pound per square inch—a pressure indespensable to continuous melting, as in the Bessemer manufacture. Rotatory blowers with sliding pistons or rubbing surfaces of any kind, may indeed be kept tight if constructed with sufficient cost, and carefully cleaned and lubricated. The advantage of Root's rotatory blower is that it has, strictly speaking, no rubbing surfaces. The floats, or rotatory pistons, are so shaped that the projections of the one exactly fit into the hollows of the other, without the need of sliding vanes. There is of course a very thin space between the floats, through which a thin film of air leaks back, but this loss is reduced to a minimum by means of a stiff paint or plaster of black lead and tallow, which is applied to the floats and soon moulds itself to fill the spaces that would otherwise promote excessive leakage. But, as in all other machinery with which we are acquainted, the best materials and workmanship pay best in the long run. The shrinkage or the loosening of the wood forming the floats, by reason of improper seasoning or fastening, soon cause excessive friction as well as leakage. Perfectly seasoned wood floats, secured as well as they *can* be to steel shafts and cut gearing, certainly answer well; this we know from experience with not less than three of these blowers, of the largest sizes. At the same time, we think the extra cost of cast-iron floats, planed or dressed by special tools and gauges to a perfect fit, and revolved by several sets of wide-faced cut gears, so as to avoid back lash and wear, would pay. The power wasted in driving a noisy or leaky blower, would cost more than the most accurate construction.

Elastic Collodion Cement.—Ordinary collodion is made by dissolving eight parts of gun-cotton in one hundred and twenty-five parts of ether and eight parts of alcohol. When used as a cement or varnish it becomes very hard, cracks easily, and peels off. It may be rendered elastic by the addition of four parts of Venetian turpentine and two parts of castor-oil. When intended for surgical purposes, as a varnish, which when dry forms a perfectly close-fitting plaster, it has been found that the addition of some glycerine to the ordinary collodion, in which it is dissolved to a small extent, makes a varnish which adheres strongly to the skin, does not crack, and, on account of its elasticity, does not crease the skin.

Wire-Rope Transport.—The practical value of the wire-rope transport system, invented by Mr. C. Hodgson, C. E., (see V. N's. Mag. Vol. I, p. 334,) is now being recognized by those engaged in working mines. Sir G. S. Robinson has given an order to the Wire Tramway Company to construct one of their patent ways, for carrying iron ore from his quarries to the Cransford Station.

ARTIFICIAL STONE.—Mr. Hodgsol, the proprietor of four patents on artificial stone, exhibited his process for manufacturing this stone at a late meeting of the Polytechnic Association of the American Institute. The stone consists of sand cemented together by means of oxalate of lime. The inventor takes two or three parts of sand to one of lime, or rather lime slacked with a solution of oxalic acid. The materials are carefully mixed and then pressed in a mould, where they quickly set. The articles are then transferred to a bath containing a solution of oxalic acid, where in a short time they become hard. Oxalic acid forms with lime a compound of great insolubility. Indeed, the oxalate is the most insoluble of all the salts of lime. A great deal has been said about the superiority of the cements made by the ancients. This is due partly to the influence of time, and partly because the poor cements have disappeared. When lime and sand are left in contact for many years a chemical union takes place, and a true silicate of lime is formed. Hydraulic cement requires the presence of alumina. The Rosendale cement contains carbonate of lime with silica, alumina and magnesia. The French, in making the Suez Canal, employ the mud of the lakes, the sand of the desert and lime, which they mix, bake in the sun and use for the construction of piers, etc., without the application of any fire. This stone is about equal in hardness to Cayenne stone.

ELECTRO-MAGNETIC ENGINES ON BOARD SHIP.—Mr. John Tawse writes to "The Engineer" as follows: Some years ago, when in India, I had a boat on one of the salt lakes of the Coromandel coast, and from experiments I then made I became impressed with the idea that there is an immense mechanical power lying dormant in the simple and natural *galvanic action of salt water on the sheathing of vessels.* Electro-magnetism has hitherto failed as a motive power on the score of economy only. The form of battery used is too expensive, owing to the use of strong acids acting upon a comparatively small surface. Also in this case the electric current is deficient in quantity for mechanical purposes. What seemed to be wanted was a very large area of metallic surface, acted upon by an excitant strong enough to evolve a powerful current, yet not sufficiently so to wear or corrode the plates in a very perceptible degree. I have since published the idea which this gave birth to in several of our scientific journals. But as I have now worked it out to completion, both by calculation and experiment, I detail it herein for the information of your readers.

A vessel to be fitted with an electro-magnetic engine attached to an ordinary shaft, is sheathed on one side with copper, and on the other side with zinc. The sheathing is laid on over sheets of gutta percha in order to insulate it from the woodwork of the vessel. The nails necessary for this purpose are driven in such a manner that they are nowhere in metallic contact with any part of the sheathing. The two sections of copper and zinc sheathing thus form a battery, acted upon and excited by salt water alone. If any one acquainted with the subject will calculate the result of galvanic action on so large a surface as the area of immersion of a floating vessel, they will perceive that it is the right application of it alone that is wanted to convert it into a powerful mechanical force.

The vessel being so sheathed, a wire from each section of course conducts the current to the electro-magnetic engine. In my first experiments I had a large magnet to work a keeper in connection with a crank in the usual way. Since then I have adopted a mode of multiplying the power enormously. Thus the wires are connected with a thick, small-sized electro-magnet in the first instance. In front of its two poles an armature is made to rotate with great velocity, and the augmented current thus produced is carried to an arrangement of two very large magnets working reciprocally in such a way that the keeper, or soft iron beam between them, which works the crank axle of the screw, flows the current into each separately at every stroke, charging it just before the moment of contact. As regards the wear of the plates, it would be no greater than in the case of ordinary sheathing, with this advantage, that no sea-weed or barnacles would adhere to sheathing in constant galvanic activity; ordinary copper sheathing would be quite free from them if the galvanic circle were complete. In fitting the above engine to a vessel the rotating armature working before the first magnet would have to be driven by a small steam engine.

ON THE COST OF WATERWHEELS IN ENGLAND. Mr. Robert Sanders writes to the "Mining Journal" as follows: After fifteen years' practical experience in working all kinds of mining machinery by waterwheels, I am prepared to assert that a wheel 10 ft. in diameter, 3 ft. breast, should not cost about 10*l*.; one of 24 ft. diameter, 4 ft. breast, 120*l*.; or one of 40 ft. diameter, 3 ft. breast, 220*l*. I will quote one instance just to show something about the price of waterwheels. At the Carmarthen United Lead Mines, in South Wales, I had two wheels erected, one of 34 ft. diameter, 3 ft. breast, with cast-iron axles, centers and shrouding; the arms, soling and buckets were of yellow pine; there were also the crank-pin and connecting-joint for sweep rod. The other was 24 ft. diameter, 4 ft. breast, with cast-iron axle centers and shrouding; the arms, soling and buckets were of red, or pitch, pine; also crank-pin, connecting-joint, etc. Both of these wheels were made per contract. The cost of each, including erection, was as follows: 34 ft. diameter, 164*l*. 10s.; 24 ft. diameter 119*l*. 10s. The latter, including wheel-pit, etc., when ready to work, cost altogether 144*l*. The former had no wheel-pit, but worked on a frame, like a grindstone, made of American pine log, and the whole expense when ready to work did not exceed 230*l*.

HOW TO TEST THE LUBRICATING POWER OF OIL. It is a matter of importance to the mechanic to be able to say what amount of friction a particular oil can overcome as compared with another oil. This is done by an apparatus called an "oil-tester," of which a new form, devised by Mr. T. R. Shaw, is thus described: On a vertical shaft fitted in bearings is fixed a disc, on the upper surface of which rests a circular or partly circular block, the two surfaces in contact being preferably finished as true plans. The lower disc is caused to revolve rapidly by suitable means, the continued rotation of the block being prevented by a cord, one end of which is attached to the side of the block, the other end being attached to a spring balance, or to a weighted and gradual lever. The block is kept in position on the revolving disc by means of anti-friction bowls, which are so applied as not to interfere with the rotation of the block. A thermometer is fixed in the center of the block. A small portion of the lubricant to be tested is applied to the disc, the metal block is placed in position, and the lower disc is caused to revolve until a certain temperature which has been fixed upon as suitable for all seasons, as for example 70° Fahr., is indicated by the thermometer, when the test of the oil is commenced by noting the frictional resistance indicated on the scale of the spring balance, readings being taken from the scale at intervals during the continuance of the experiment.—*Scientific Opinion.*

The Velocipede as a Mechanical Agent.—The practical value of the velocipede as a means of locomotion has been thoroughly discussed in a well-considered paper by Mr. Lauder, C. E., read before the Liverpool Polytechnic Society. As advantages and disadvantages of bicycles, tricycles, etc., are very equally balanced as compared with each other, Mr. Lauder's conclusions may be considered to apply equally to all kinds of velocipedes. The velocipede possesses *no* advantage; that is to say, a man can, with equal exertion, walk or run quite as far in a day of eight hours as he can travel with a velocipede in the same time. Mr. Lauder, being a velocipedest himself, has given the velocipede all the advantage in the argument that was at all possible; yet he can only show that, although for a journey of a few minutes duration a speed of 24½ miles per hour may be obtained, no more than 30 miles in the day of eight hours can be traversed. Mr. Lauder is of opinion that, as a means of traveling, the velocipede has very little chance of coming into use, although as an instrument of healthful exercise it is worthy of consideration.—*Builder.*

Speed in Travel.—In a single second a snail travels one five-thousandth of a foot; a fly five feet; a pedestrian, at ordinary gait, five and three-tenths feet; a camel six feet; an ordinary breeze ten feet; a rapid running stream twelve feet; a trotting horse twelve feet; a whale twelve and three-tenths feet; a fast-sailing ship fourteen feet; a reindeer, with sledge, twenty-five feet; a locomotive engine twenty-nine feet; a skater thirty-six feet; a race-horse forty-one feet; a tempest fifty feet; a swiftly thrown stone fifty feet; an eagle ninety-five feet; a carrier-pigeon four hundred and eleven feet; a rifle ball one thousand five hundred and ninety-five feet; a twenty-five pound cannon ball two thousand two hundred and ninety-nine feet; a point of the earth on the equator two thousand four hundred and fifty-one feet; the center of the earth around the sun four miles; a ray of light one hundred and ninety-five thousand miles.

Atmospheric Signal for Ships.—Messrs. MacIver and Co. have introduced Messrs. Wier and Co.'s atmospheric telegraph signals into the Scotia and other large steamers of their fleet. The apparatus may be briefly described as consisting primarily of a small air-chamber to which air has perfect access. In this chamber an elastic disc is placed which, acted on by a lever, compresses the air in the chamber and propels it through a metallic tube of small diameter to any part of the ship with which it is considered desirable to communicate. The air so propelled rings a signal bell in the first instance to secure attention to the signal transmitted; the action of the transmitted air at the same moment that it strikes the bell lifts a small and delicate opaque shutter, revealing under it the word or words of the intended order. The chief point where directions must be given is the locality in which the commander of the vessel is placed, such as the bridge in the case of an ocean-going steamer. Here the handle of the instrument is placed, the whole revolving on a pivot, so that the handle is pressed down to the point which will indicate at a distance the command issued. This is guided in the mode of working by a dial inscribed with the words intended to be communicated.

Proposed Canal Between the Bay of Biscay and the Mediterranean.—The project of establishing through the Valley of the Garonne (France) a canal for large navigation has often been mooted; but there is now a new plan for this undertaking, under the auspices of M. Staal de Magnancourt. The proposed canal will admit not only merchant ships of the heaviest tonnage, but also men-of-war and transatlantic steamers. A port is to be established in the Gironde, just below Bordeaux, and another on the Mediterranean. The cost of the scheme is estimated at 442,000,000f., and the cutting of the canal would occupy six years. The plan, if carried out, will materially shorten the navigable communication between England, the north of Europe, and India, for it will in fact be a continuation of the canal of Suez.

The Fast Voyage of the Scotia.—The Cunard mail paddle-steamer Scotia still continues to maintain her supremacy on the Atlantic. Her last passage from New York to Liverpool was one of the shortest on record, she having made the run to the Mersey, including detention at Queenstown, but allowing 4 hours 40 minutes for difference of time, in 9 days and 19 minutes. She had S. S. W. wind on the day of sailing and afterwards moderate easterly breezes throughout. On the 13th she had logged 254 miles, 14th 326, 15th 330, 16th 322, 17th 31, 18th 641, 19th 340, 20th 320, 21st, to noon, 339, being an average speed of nearly 14 knots an hour. The engines of the Scotia are of great power, and with moderate winds she leaves all competitors far in the distance. The Inman screw steamer City of Paris and the Cunard screw steamer Russia are the only two ships which at all approach her in point of speed.—*Engineering.*

Iron Ship Building in New York.—An estimate was recently obtained by a New York shipping firm, for the building of a first-class iron sailing vessel in this country, but it now appears that the vessel is to be built in New York, more favorable terms having been obtained there, and that only the wire rigging, anchors and chain cables, are to be supplied from England. This, we understand, will be the first American built iron sailing vessel to cross the Atlantic.—*Mechanics' Magazine.*

New Fairbairn Engines.—The Fairbairn Engineering Company have now in hand, and will be shortly ready to exhibit, a set of 60-horse engines, constructed upon an entirely new principle, which, besides possessing other important advantages, will consume probably less than half the quantity of coals required by the best steam engines at present in use.—*British Enthusiast.*

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PAYING AND NON-PAYING LOAD.

A paper read before the Civil and Mechanical Engineers' Society, by Mr. B. Haughton, C. E., on "The paying and non-paying weights pulled by the locomotive engine in 1867."

The railway statistics published by the Board of Trade, annually, as far as they go, are of vast importance in determining the quantity and cost of the useful work done by the locomotive. In a country such as the United Kingdom, possessing 14,247 miles of railway (or 22,091 miles of single line), which has been made at a cost of £502,263,000, equal to £35,253 per mile (or £22,736 per mile of single line); in which the receipts from railway traffic are £39,480,000 per annum, or £119,636 per day (in all such calculations I assume that the year contains 330 working days); in which 287,688,000 railway trips (not including those of season-ticket holders) are made in the year, equal to 871,781 trips each day, each trip 12¾ miles in length; in which 148,253,800 tons of goods, minerals, etc., are carried per annum, equal to 449,250 tons each day, each ton pulled over say 25 miles; in which 6,328,490 trains are started per annum, equal to 19,177 trains each day; in which the locomotive travels 148,542,827 miles per annum, or 450,129 miles each day; which has been the cradle of the railway, and in which it and its complement, the locomotive, were first invented, constructed, and brought into operation—in such a country the question of the administration and conduct of the railways must be a paramount one; and we cannot, as its people, be said to have done justice to this magnificent piece of mechanism until we shall have so investigated its economy, and the science of its action and effort, as to place beyond dispute the laws of its existence.

It is particularly desirable that such should be studied at the present day; there is, just now, a lull in the railway atmosphere; railway construction, incessant for the last 40 years, has at length ceased; the engineer is idle, the capitalist, without whose co-operation he dare not lift his hand, stands aloof; the public look on and suffer from the estrangement, and their occupation in this department of their manifold labors being gone (for the construction of 552 miles of single line per annum since 1827, with its attendant expenditure of £12,500,000 yearly, must have been to them a source of much and very profitable business); they began during their enforced leisure to examine and criticize the natural history of the giant that they have created, with the view to bending him to a more tractable and economic servitude; and, in truth, most wildly and inconsiderately have they approached the investigation. We cannot altogether blame them for having placed themselves so far under the guidance of *doctrinaires.* He who, by virtue of his office, ought to have been their guide in their attempt to solve the various questions at issue has not come forward to assist them with his counsel, and out of his practical and special knowledge of the situation. The engineer, which an immense material developement in the current century has produced, has been so entirely absorbed in, and devoted to, the physical side of the railway question, that he really has not had time to consider its moral aspect. As soon as he shall have done so, and explained the condition of affairs, we may reasonably expect that the aforesaid public will become contented with "things as they are," as the intelligent British public always is, when light is given to it, and when it is made aware by the logic of facts that "things cannot be otherwise."

I hardly ever remember to have seen the truth so persistently distorted as of late, by certain pamphleteers, magazine writers, and ambulatory orators, in regard to this question. In one case a most elaborate literary picture has been drawn, in an article styled "The Great Railway Monopoly," the object of which appears to be to induce the Government to undertake the management of the railways of the United Kingdom; to confer upon the traveling public the benefit of low fares; and to prove indirectly the total incapacity of those who have the control and direction of the railway *menage* of the country. The article is remarkable for the display of much research, and, in short, conveys the idea that it comes from the hand of an accomplished and fluent compiler. It, however, reminds the engineer of a grand and boldly designed arch of masonry under construction; it is perfect as to the material selected, its foundations are on a rock, its abutments, its counterforts and haunches are undeniable, but it fails to support itself on the withdrawal of the centering, because of the omission of one simple, though indispensable feature—the key—which, in the case of this slap-dash article, must be supplied by the engineer, and the absence of which stamps the writer as being a literary conjurer rather than a practical man. With such instructors as these alluded to, and the magicians of the Belgian State lines, it is not to be wondered that the English public are disturbed as to the condition of their railways. It is not surprising that, at the first blush, they should believe themselves to be the victims of a selfish association of monopolists, and that this immense property is tended and controlled by an executive of quacks, who are guided by the leading idea that high fares alone will generate income; never was a more unfounded belief fostered.

The railways of the United Kingdom, at the present day, are conducted by an accomplished, scientific, and highly skilled body of experts, who know their business, do it, and don't talk about it, and who, moreover, take out of the locomotive all they can, and present it freely and exuberantly to those whom it is their interest, as well as their pleasure to accommodate—the traveling community; as shall presently be shown, this is, as the "Times" has lately stated, "the best served traveling community in the world," though I cannot endorse the final phrase in the sentence, that it is "the most ungrateful," because ingratitude is a vice of the weak and the unintelligent, and I cannot admit that my countrymen belong either to the one or the other class, but the rather that, having been made aware of the actual condition of affairs, they will accept it as being, on the whole, the best possible, considering all the circumstances of the case, and will unite with those who are only too well pleased to be assisted by them in concerting means for the elimination of such minor defects of the railway system as exist, and which are only those that belong to every human institution, but which, nevertheless, we must combat unceasingly, so as to attain as much perfection as our knowledge of the science involved will admit.

To begin, accordingly, the work done by the locomotive in 1867, the last year for which the Board of Trade returns have been published, was, viz:

3,924,624 passenger trains pulled 19.08 miles each.

	Tons.	Per cent.
Paying weight	27,472,368	4.89
Non-paying weight	533,748,864	95.11
	561,221,232	100.00

2,403,866 goods trains pulled 30.64 miles each.

	Tons.	Per cent.
Paying weight	146,635,826	30.34
Non-paying weight	336,541,240	69.66
	483,177,066	100.00

6,328,490 total number of trains pulled 23.47 miles each.

	Tons.	Per cent.
Paying weight	174,108,194	16.67
Non-paying weight	870,290,104	83.33
	1,044,398,298	100.00

Horizontal mile tons.

Passenger trains	10,708,101,106
Goods trains	14,804,545,302
	25,512,646,408

This work was done by 8,619 locomotives, showing work done by each, per annum, 2,960,047 horizontal mile tons; work done by each, per day, 8,969 horizontal mile tons, equivalent to 382 tons pulled 23.47 miles per day, and further, 17,234 miles run by each engine per annum.

Taking the 23.47 miles, the actual average distance run by each train per day, as consisting of an ascending gradient of 1 in 300 for half the distance, or 11.735 miles, and a descending gradient for the remaining half; and assuming 26 miles per hour to be the average speed of each train, equivalent to an exercise of horse-power, as under:

Train mileage of Board of Trade Returns.

$$\frac{148,542,827}{3,924,624 + 2,403,866} = 23.47 \text{ miles run by each train per day.}$$

Total train tons.

$$\frac{1,044,398,298}{3,924,624 + 2,403,866} = 165.03 \text{ tons' weight of each train.}$$

Average inclination, 1 in 300 up for 11.735 miles; and 1 in 300 down from the same distance.

Average speed, 26 miles per hour.

From these data are obtained the results:

$$\frac{26 \times 5,280}{60} = 2,288 \text{ ft. run by train in 1 minute.}$$

$$\frac{2,288}{300} = 7.626 \text{ ft. lift of train in 1 minute.}$$

$$\frac{165 \times 2,240 \times 7.626}{33,000} = 85.41 \text{ horse-power due to lifting the trains.}$$

$$\frac{165 \times 9 \times 2,288}{33,000} = 102.96 \text{ horse-power due to friction, etc., at 9 lbs. per ton.}$$

$+85.41+102.96=+$ 188.37 horse-power required in ascending the incline.

$-85.41+102.96=+$ 17.55 horse-power required in descending the incline.

$+188.37+17.55=$ 205.92 horse-power exercised throughout the average run of 23.47 miles.

Trains. Trains per day.

$$\frac{6,328,490}{330} = \frac{19,177}{8,619} = 2.22 \text{ trains pulled per day by each engine.}$$

Each train pulled 23.47 miles, at 26 miles per hour, gives 54.16 minutes occupied in the average journey.

$$54.16 \times 2.22 = \frac{120 \text{ minutes.}}{60} = 2 \text{ hours}$$

205.92 horse-power $\times$ 8,619 engines $=$ 1,774,824 total horse-power exercised for two hours each day of 330 days per annum, in behalf of the traveling public.

Considering that these engines may be held on the average to be capable of exercising 400 horse-power each without forcing; the 206 horse-power actually made available will perhaps be considered too small a percentage to take out of each engine, but it will be understood that it is not possible to render useful the maximum power of the total number of engines in the country, for these reasons: that a certain portion must be held in reserve in case of ordinary accident to running engines; that another portion will be engaged as bank engines, and in shunting trains about the stations; that a large proportion of the whole will stand in the sheds for cleaning, and in the shops to undergo the repairs due to the daily wear and tear of an exceedingly complicated and perishable machine; and that, over and above all these requirements, an ultimate reserve will be necessary in order to make sure that a provision shall exist against all eventualities, and that in no possible case shall the company fail to perform their duties to the public punctually, as advertised in the time bills. These results cannot be taken as illustrating the work to be gotten from individual engines, but only as being useful in comparing the total work of one year with that of another in the same country; in comparing the work done in one country with that in another; and, above all, and eminently, in showing a people how much they take from their machinery in gross, with the object of exhibiting the weaknesses of the system, so as to effect such reforms as shall lead to improvements in organization and administration therefor.

In reviewing the foregoing figures, I shall ask your attention to two salient matters therein exhibited, the first of which is that I have reduced the work done to horizontal mile tons, and that I believe this to be the only true mode by which a railway company can accurately test the nature of its operations; and, secondly, to the extraordinary preponderance of the figures indicating the non-paying weight pulled as compared with the paying weight, viz: Firstly, the usual mode of estimating the work done, as practiced by boards of directors, is that by train mileage. The train mileage of one half-year, exceeds that of the corresponding half in the previous year, and this is hailed as a matter of congratulation from the chairman to his proprietors; or the increased income per train mile of the half year has exceeded that of the corresponding six months of the former year by a certain percentage, which is equally a cause of satisfaction to his audience; whereas, it is quite within the range of possibility, and has no doubt happened before now, that each of these apparently pleasing results of the half-year's work has been nothing less than a captivating illusion; for, in the first case given, that of an increase of train mileage, the latter may have increased without bringing an increase of revenue, and may have brought with it a positive loss; and, in the second case, that of an increased income per train mile, the same may have arisen in consequence of a reduction of mileage, and may have existed co-incident with a falling off of revenue. The train mile is not a measure of the useful work done, because the weight of the train is not told; given the weight of the train, however, subdivided into its paying and non-paying weights, and a basis of calculation is afforded, which places the work done beyond cavil.

In order to attain this object, it will be necessary that the paying and non-paying weights of each train started shall be registered, as well as the distance traveled by each vehicle. This, though causing some extra office work, will amply pay for itself in the long run. I have endeavored to reduce the work done, as given in the Board of Trade statistical tables, to the horizontal mile ton by rating the weights of the average trains of the year as follows. It will be observed that some of the items in the tables are assumed. I have determined their value as best I could, from the most reliable sources I have been able to consult; the remaining items are taken from the Board of Trade returns, viz:

Weight of the average passenger train in 1867—

Non-paying load.		
Engine and tender............	50 tons.	
Seven carriages	56 "	
Two breaks..................	10 "	
		116 tons.
Empty carriages, etc., to be pulled back, say $\frac{1}{6}$th of above		20 "
Paying load.		
73 passengers, with luggage, etc., at 2 cwt. each......................		7 "
Total		143 tons.

I have chosen seven as a fair average figure for the carriages to each train. This number of composite carriages should contain, if full, 196 persons, narrow gauge; and in corroboration of this rating, I may quote Mr. Robert Stephenson, who, in his address to the Institute of Civil Engineers, in 1866, rated the then trains as capable of holding on the average 200, while not actually carrying over 100 passengers. It appears, from the Board of Trade returns, that the number of passengers has decreased since then, doubtless owing to competition, and the wish to render traveling more attractive by the running of an increased number of trains, since only $73\frac{1}{4}$ passengers were carried per train in 1867; or it may have been more directly due to the practice of sending through carriages to all the principal stations with the more important trains, thus saving their occupants the necessity of changing from one carriage to another *en route.* The empty carriages to be pulled back with their attendant portion of the weight of the engine, consequent on the irregularity of flow of the streams of traffic in opposite directions, is a fact that cannot be evaded, I have rated it at one-sixth the non-paying weight.

Some persons may take exception to the rating of the assumed items, but, even should they be found strained or faulty, which I have taken all pains to prevent, the amount of their error, however largely it may be estimated, cannot materially affect the issues.

Weight of the average goods train was, in 1867—

Non-paying load, viz:		
Engine and tender..........	50 tons.	
Two breaks................	8 "	
Six goods trucks at $3\frac{1}{2}$ tons each, to carry 3 tons......	21 "	
Six mineral trucks at $3\frac{1}{2}$ tons each, to carry 7 tons each..	21 "	
		100 tons.
Of the above, to be sent back as empties, two goods trucks six mineral trucks........	28 tons.	
One-fourth engine and tender, with empties.............	12 "	
		40 "
Paying load.		
Goods	19 tons.	
Minerals	41 "	
Six and a-half head live stock	1 "	
		61 "
Total		201 "

In this table the detail of the item 61 tons is taken from the Board of Trade returns; the other items are assumptive (under certain restrictions, which will be apparent), still not to be omitted. These two tables give the average weights of the passenger and goods trains of the year; by multiplying their several sums by the total numbers of trains, passengers and goods respectively, run in the year, as given in the returns, I have arrived at the great totals given before.

The second point to which I have asked your attention is that of the immense excess of the non-paying weight of the trains over and above the paying weight. This is a subject which is frequently treated in the scientific publications of the day, and which has been discussed at meetings of this Society, but I am not aware that it has been hitherto considered in connection with the Board of Trade returns. In the annual address, which I had the honor to give to this Society in October, 1868, I alluded to the subject of non-paying weight. I then gave an estimate of what I believed to be the proportions in which these two divisions of the total weight of the train are to be found. The non-paying weight, large as it was, I now find was understated, as shown by the astounding results extracted from the returns. This was in part owing to the fact that the figures were drawn from a much smaller railway circle than that from which the returns immediately before us have been computed.

The proportions of the paying weights of trains run in 1867 were, viz:

Passenger trains.
Paying weight, 4.89 per cent of the total weight of the train.

Goods trains.
Paying weight, 30.34 per cent of the total weight of the train.

Total Passenger and Goods trains.
Paying weight, 16.67 per cent of the weight of the whole train.

Or, in simpler phraseology, it takes 19 tons of train equipment to carry one ton of passengers, 2¼ tons of the same to carry one ton of goods, and, in gross, 5 tons of equipment to carry one ton of paying load.

That the public are not acquainted with these facts is, I believe, the secret of their discontent with the management of our railways. They place themselves willingly under the direction of theorists, who are not competent to realize the situation. Relieve them from this state of suspense in which they are placed, make them familiar with the reason why they cannot hope for a reduction of fares, and they will rest content, and railway property cannot fail to be the gainer thereby. Show them that the experience of the Post-office cannot be taken as a guide for the management of railways, because a letter weighs practically nothing, as I have endeavored to show in the address before mentioned, and that its numbers may be increased almost indefinitely without extra cost of carriage, whereas a passenger will weigh two tons, including his share of train equipment; and, moreover, that each passenger carried, in addition to the usual numbers, will bring an additional weight of two tons with him. Show them that the fares charged by excursion trains cannot be taken as a guide, because the conditions under which they are run are not those required in the conduct of the common traffic trains of the country. Show them that the extremely low fares charged on the Belgian railways cannot be taken as a guide, because, firstly, what are commonly called the Belgian railways, and notably so in the second report of the Railway Commission of 1868, are not the Belgian railways, but only a fraction of them, that is to say, 535 miles out of 1,819; secondly, that they were constructed by the Government, before private railway enterprise had commenced in Belgium, who naturally selected the most promising lines of country, and are, in fact, possessed of the cream of the traffic of the land; thirdly, that these lines have cost £18,000 a mile as against £36,000 for the English lines; fourthly, that these lines have been charged with no parliamentary expenses; fifthly, that land is of far greater value in England than in Belgium; sixthly, that labor is dearer in England; seventhly, that the speed of the Belgian trains is considerably less than that usual in England. That all these things combine to make the working of railways more costly at home, and so to produce higher tariffs of fares and rates; and, finally, that no later than this month, M. Malou, Belgian senator, and well versed in the railways of that country, has shown, in a pamphlet which he has published, that the glowing promise of a new railway era, to be inaugurated by these gifted Belgian legislators, is only a juggle and a delusion, and that the Government must immediately raise their fares considerably, unless they are prepared to work their 535 miles of line, having cost £10,000,000, with an utter disregard of the ordinary principles of economy and trade, and at an enormous loss per annum. Lay all these facts and views of the question before the traveling public of England, and they will quickly wipe the film from off their eyes that now rests there, and be led to confess that, after all, the men who have invented and perfected the locomotive and the railway, with its belongings, and instructed the world in the art of working and using it, are as likely to know how to tend, and direct, and manipulate it with skill and sagacity, as are their continental and other pupils.

The English engineer knows that natural

and economic laws must eventually prevail, no matter how the public may wish to dispense with their action; he knows the ways, paths, and tendencies of these laws; he knows how to respect them, as respected they will be; while he also knows how to bend them to his educated will. With these laws as his guides, and with the forces which nature permits him to wield as implements, he goes on in a safe and sure road of progress, and, as he advances, hardly turns his head to reply to the dreamers and triflers, who preach from the stump and the journal the reversal of the order of nature.

This immense dead or non-paying weight has ever been a difficulty with the engineer. Dead weight has no doubt increased of late—engines are made heavier, hence more adhesion, less liability to become derailed, and greater economy of fuel in working; carriages are made longer, hence there is more space for the legs of passengers; they are made higher, hence more facility for moving when in an erect position; the timber is of large scantling, hence more steadiness and durability—all these changes have been changes for the better, the traveler, in consequence, is more convenienced as well as physically safer than before—the latter a boon that cannot be over-estimated; he is actually 1,000 per cent safer at present sitting in a railway carriage in motion, than when walking in the London streets. The Briton of the age, in short, travels fast and securely; faster, indeed, than the representative individual of any other nation; he is in the condition of the man who lives fast, and builds a large and comfortable mansion for his gratification; its dimensions are greater than are absolutely necessary for his wants, yet he can afford the cost and he defrays it. The Briton must do likewise if he wishes to travel fast.

Reduction of non-paying weight is practicable, but it implies a reduction both of the rate of speed and of convenience, and it is not likely that it can be attempted in the face of the long enjoyment of these luxuries which the public have possessed. The receipts per mile from the 73¼ persons who traveled per train run in 1867, were, viz:

	Persons.		s. d.	Corrected income per mile.
1st class......	8¼	at 2d. per mile,	1 4¼	1 2¾
2d class......	20	at 1½d. "	2 6	2 3
3d class......	45	at 1d. "	3 9	3 8
	73¼		7 7¼	7 1¾

The column headed "Corrected" shows the correct figures, having made the proper deductions because of return tickets, which may be taken at 60 per cent of the whole number of tickets issued for 1st and 2d classes. This 7s. 1¾d. per mile must not be confused with the 4s. 9d. per train mile of the returns; the first is the income per mile run by the 73¼ passengers, the average mileage run by each passenger being 12¾ miles, while the average mileage per train was 19 miles.

The following details may be useful, viz: 73¼ passengers carried in each of the 3,924,-624 passenger trains run. Paying and non-paying weights of each train 143 tons, being a total weight per passenger of two tons. Total weight of train per one ton of passengers equal to 20 tons 8 cwt. 60 tons goods and minerals, and 6½ head of live stock carried in each of the 2,403,866 goods trains run, paying and non-paying weights of each train 201 tons, being a total weight per one ton of freight of 3¼ tons.

Each passenger train, weighing a total of 143 tons, was pulled over a distance of 19.-08 miles, bringing a revenue of £4 11s. 4¾d., equal to

	d.
Per mile ton of paying weight..............	8.2
Per mile ton of total weight of train.........	.40

Each goods train, weighing a total of 201 tons, was pulled over a distance of 30.64 miles, bringing a revenue of £8 19s. 2¾d. equal to

	d.
Per mile ton of paying weight	1.14
Per mile ton of total weight of train.........	.34
Passengers revenue per head per train mile..	.78
Passengers revenue per head per mile actually run by each passenger..................	1.17

These figures lead to the vexed question, viz: the relative paying properties of passengers and goods, which is shown in the items, as above, viz:

	d.
Passenger revenue per mile ton of total weight of train..................................	.40
Goods revenue per mile ton of total weight of train	.34

These figures are not strictly accurate, while sufficiently so for our purpose, because we know from the passenger revenue per head per train mile of .78d., that each passenger cannot have traveled the whole 19.08 miles run by the passenger train. I find that the actual distance run by each passenger was about 12¾ miles, or three-quarters more than the distance run in 1855, as given by

Mr. Robert Stephenson in his address to the Institute, in 1856, before alluded to. The precise distance run by each ton of goods pulled is not so easily found. However, all things considered, the deductions for these drawbacks of passenger and goods mileage from the 19 miles and 30¾ miles run, will not cause any material error in the representative fractions .40d. and .34d., the incomes per horiz. mile ton, respectively, as the deductions would only apply to the paying weight sections of the train, which in each case is small as compared with the total weights.

These fractional figures would place the advantage on the side of passenger traffic to the extent of .06d. per horiz. mile ton, but against such is to be placed the serious debit of 90 per cent more speed, also 90 per cent more of capital invested in vehicles, valuing carriages at £200, and trucks at £60 each, the capital invested in the latter being, viz:

Carriage capital, per ton of freight pulled per annum .... 3s. 9d.
Truck capital, per ton of freight pulled per annum .... 2s. 0d.

While to its credit is to be placed, say, 50 per cent less concussion, and the carrying of 75 per cent more freight per vehicle, etc., viz:

27,354 carriages carried 27,472,368 tons, or 1,004 tons per vehicle.
247,048 trucks carried 146,635,826 tons, or 593 tons per vehicle.

A debtor and creditor account would stand thus—

PASSENGER TRAFFIC,
AS AGAINST
Dr. GOODS TRAFFIC. *Cr.*

90 per cent more speed.	17 per cent more revenue per mile ton of total weight pulled.
90 per cent more vehicle capital invested per 1 ton of paying load pulled.	50 per cent less concussion, viz: load carried 12 cwt per foot of wheel base, as against 20 cwt. to 40 cwt.
	75 per cent more paying load carried per vehicle per annum.
	12 per cent greater facility in reception and delivery of paying load.

I shall not now strike the balance; the advantage, however, at first sight, is on the side of goods traffic. If the two sides should be found on a line, it will be a remarkable proof of the sagacity of railway managers, in that they succeed in making the two great divisions of traffic revenue contribute equally to the general account.

I must not forget to acknowledge my obligations to Mr. Frederick T. Haggard, of Burnham House, Kent, for the assistance which I have received from him while investigating this question, as well as for the hints which I have taken from his valuable pamphlet, entitled "A Mile of Railway," published last February.

The moral which I have endeavored to make this paper convey, is this: that so long as the railways of the United Kingdom shall carry passengers and their train equipage at .40d., or two-fifths of a penny, per ton per mile, at an average speed, while running, of 34 miles per hour, and goods and minerals, with their accompanying dead weights, at .34d., or one-third of a penny per ton per mile, at a speed of 18 miles per hour, the public cannot complain.

If they will take a common sense view of the question, and compare these rates and speeds with those of such other modes of traction as they are familiar with, and further, compare them with those of other countries, giving their own country credit for the many and great conveniences and accommodations which the system confers upon them, as well as taking due cognizance of the quality and price of the material out of which the fabric is made, and upon which it is built up, I feel assured their verdict will agree with that before quoted—that in the matter of railways they are "the best served community in the world." These returns disclose the strange facts that the average British passenger weighs two tons, with train accessories, and that the ton of goods, etc., weighs 3¾ tons; by no known processes can these enormous multiplication of original net weights be reduced, consistent with affording that amount of personal security, and comfort, and accommodation now enjoyed; let them, in their future deliberations on this subject, relinquish the idea which has so long clung to them, and which has been so ingeniously and persistently placed before them, that a railway passenger is a featherweight—a letter or a newspaper, as it were—and that he may be treated accordingly, let them try to realize the facts as stated, as to the actual total of paying and non-paying weights pulled, and the enormous energy developed in order to produce the effect expressed in the figures as before given, viz: 25,512,646,408 horiz. mile tons.

These, combined with the figures representing the wear and tear of material, and the labor expended in the maintenance of the system, will, perhaps, convince them of what an exacting, devouring, and insatiable monster it is that they have called upon to minister to their lately-born wants, and will go far to reconcile them to the existing tariffs of fares and rates, which, no doubt, competition and the wish to act in a just and liberal spirit to all parties concerned, on the part of railway executives, has already reduced to the lowest admissible rate. I believe that these are amongst the "things not generally known," and that when generally known they must tend to promote and strengthen that cordial understanding which ought to exist between the railway proprietor and the traveler by railway, and so without fail to increase the confidence of the investing public in this great property, and as a necessary sequence, to enhance its money value.

THE FAIRLIE STEAM CARRIAGE.

From the "Mechanics' Magazine."

The name of Mr. Robert F. Fairlie has, for some time past, been brought prominently before the public in connection with the economical working of railways. The Fairlie engine is well known to our readers, and a brief description of his steam carriage has also appeared in our pages. A trial of this carriage was made July 15th, at the Hatcham Iron Works, which successfully demonstrated the practicability of working the system upon railways, with curves of only 50 ft. radius. The steam carriage exhibited, and which was not quite completed, was designed to work on a metropolitan railway, at the terminal stations of which sufficient space could not be given for laying down rails on a curve of 25 ft. radius for the standard carriage to run itself round; consequently, the standard carriage had to be altered in dimensions to allow of its being turned on an ordinary 40 ft. turn-table. Hence, instead of seating, as is intended, the 100 passengers in the standard carriage, the carriage under trial only gave seating space for sixteen first class and fifty second class, in all sixty-six passengers. The accommodation per passenger is as good as is given on the best lines, and infinitely superior to the stock usually worked on branch lines. The length of the carriage is 43 ft., including a compartment near the engine for the guard. The engine, carriage, and framing all complete, in working order, but exclusive of passengers, weighs under $13\frac{1}{2}$ tons, and including its full load of passengers, $18\frac{1}{2}$ tons only. The carriage when finished complete will have a broad step or platform on each side, extending its entire length; this step is protected by a hand rail on the outside, with an arrangement for lifting it on the platform side at the doors to allow the passengers to get in and out. The object of this platform is to enable the guard to pass completely round the train at all times, and while doing so, he is perfectly safe from any accident. Passengers can also pass along the platform to the guard, so that in this manner there is an easy and perfect mode of communication between passengers and guard.

It is intended, however, in the standard steam carriage to provide a central passage inside the entire length of the carriage, leading direct from and to the guard's compartment; thus there is the most direct means of communication between the passengers and guard. The compartments in the carriages will be quite as separate and distinct as they are at present, or as the most fastidious could desire. The guard passes through the carriage at pleasure. Those in the higher classes can pass to the lower, but the lower cannot get to the higher, while all can pass to the guard when required. The standard carriage will have two compartments first class, to seat 16 persons; three compartments second class, to seat 30 persons; and four and a-half compartments, third class, to seat 54 persons—in all, 100 passengers. The machine complete, in working order, will weigh about 14 tons, and with the 100 passengers, from 20 tons to 21 tons. These carriages will convey their full complement of passengers at forty miles per hour up gradients of 1 in 100, and, as demonstrated, will pass round curves of 50 ft. radius at twenty miles an hour with perfect safety.

There are few trains on any of our railways which convey more passengers per mile than can be accommodated by one of these steam carriages. In fact, it is known that the average number of passengers, taken from the Parliamentary returns, give only about eighty passengers conveyed altogether by each passenger train in the United Kingdom, from the time it starts until it completes its journey; and this only gives about an average of 30 to 35 passengers at any one time in the train, for each mile traveled. Of course, there are exceptions to this number on our principal mail lines, but even in these cases, a greater number is the exception, and not the rule. The weight per wheel of the steam carriage being only about $2\frac{1}{2}$ tons, it follows that very light rails may be used, with everything light in proportion. The passage of such sharp curves so easily will enable us to make lines very inexpensively; we need no embankments or cuttings or heavy masonry works of any kind; therefore, lines will be made cheaply and stocked cheaply. Under these circumstances, there is no reason why every village should not have its line either direct or communication with some of the main lines, to which these light railways would act as feeders, and not like the present branch lines, which really act as suckers and not feeders. Many of these branch lines have actually cost a larger sum per mile than the parent line, over which the traffic from the particular branch would not represent more than 5 per cent, if so much, of the total traffic. Then how, in the name of wonder, can such lines pay? When a gentleman desires to open up an estate for building or agricultural purposes, the first thing he considers is the making of suitable roads through it. Now, instead of roads, there is no reason, why these light railways should not be made. In time it will come to this.

We are only, in a sense, beginning railways; we must have double, aye, treble the mileage we have at present, but every one of these miles must not only be constructed but worked in a very different manner to that in which they have been, and are being at present. We have only to consider this simple fact: the steam carriage, with 100 passengers included, weighs about 20 tons, while the tender which accompanies the ordinary locomotive, and which is perfectly useless, except to carry food for the locomotive, weighs as much, if not more. The usual passenger trains average in weight, exclusive of passengers, about 80 tons; therefore, it follows if to work 80 tons it takes 30 lbs. of fuel for the locomotive per mile, to work only 20 tons, one-fourth of the fuel would be required. The reference to fuel means oil, tallow, and every material required to maintain the engine; it means also the same proportionate reduction in the cost of maintenance of permanent way, and all charges connected with the working of railways. The proper method of working railways is to take the largest possible loads, and, consequently, fewer numbers of goods trains; so that instead of earning about 6s. per train per mile at a cost of 50 per cent, netting 3s., these should earn double the amount—say 12s. per mile—while the cost would not exceed 1s. over the 3s. spent to earn the 6s., giving a net production of 8s., instead of 3s., or about 280 per cent more.

Then, again, the passenger trains which now earn under 5s. per train per mile, and costing 50 per cent of the amount, or 2s. 6d. to earn it, could be worked with the steam carriages at a cost of about 1s. 6d. per mile, thus adding 40 per cent to the net receipts on passenger traffic. It is to be remembered that these percentages are pure gains to railway companies, the cost of management and other charges being taken as remaining the same, the profits arising solely from the improved mode of working. The Fairlie engine can haul double the ordinary loads of goods per train, without injuring the permanent way so much as is now done by the ordinary engine; and allowing for the increase in the consumption of fuel for the load taken, all other expenses remaining the same, the extra cost on each could not exceed even 6d., although 1s. is placed against this item—therefore, the profit must certainly be very great.

While on the subject, we now notice the Fairlie engine "Little Wonder," which has been built for the Festiniog Railway Company, and which has obtained very considerable notoriety from its being the narrowest gauge passenger railway worked by locomotives in existence. The line has been worked now about five years, and during that time there has not been the slightest accident of any kind; in fact, it is considered a most extraordinary line, not only on account of its gauge, which is only 2 ft., but because of its success commercially. The traffic hauled last year over this miniature line of twelve miles in length amounted to 130,000 tons of goods, and 145,000 passengers, which would be considered a very handsome traffic for a full-sized railway of the same length, and the wonder is, how it has been done. The credit is due to the able management of Mr. C. E. Spooner, managing director and engineer. The traffic has so increased that the ordinary engines are getting too small to pull the loads, and hence the adoption of the Fairlie engine, which at once enables the train loads to be doubled, without, but in a very small degree, increasing the cost of each train. The Festiniog line is, for about eleven miles, one continuous ascent of about 1 in 80, with very many curves, some of which are as small as 100 ft. radius. The "Little Wonder," although weighing but 19½ tons, fully equipped with fuel and water for the road, will haul after it 140 tons, at a speed of fifteen miles an hour for the whole eleven miles; a feat, considering the gauge and weight, that could not be accomplished by other than the Fairlie engine. The engine has eight wheels, in two separate groups of four each, each group being acted on by a pair of cylinders 8½ in. diameter. The wheels in each group are 2 ft. 4 in. diam., and are coupled together.

The extreme wheel base is 18 ft.; consequently, the engine will run with remarkable smoothness. At the same time, the wheel base of each bogie being but 5 ft., the engine will pass round curves of 50 ft. with the utmost safety at 20 miles an hour. The principle in this respect is precisely similar to that of the steam carriage passing curves of 50 ft. The fact of either steam carriages or engines being constructed to run with perfect safety round curves of 50 ft. is unprecedented in the history of railways, and places the railway world under a considerable obligation to Mr. Fairlie, who has spared no pains to perfect a system to which we wish every success.

ACCUMULATED HYDRAULIC POWER.

From "The Engineer."

The advantages in economy and convenience which attend the use, for many purposes, of accumulated power, are by no means generally understood. By accumulated power we mean power which is generated continuously, to be used at intervals without any change in the application, such as occurs in the use of a hammer, where the accumulated power is used percussively. In this case there is such a sudden application of the accumulated power as to cause very marked differences in effect from the effect of the same, were power applied in any other way; in fact, it is well known that for certain purposes it is imperative to apply power percussively; but the purpose of the present article is to deal exclusively with the question of the periodic use of continuous power as affecting the economy and convenience of machines used for manufacturing purposes. Power may be accumulated in very various ways, but it is in the hydraulic accumulator that we find the most extensive and convenient application of the principle. To the application of hydraulic accumulation we shall therefore confine our attention, and, further, we must premise that direct applications of hydraulic power, as in the hydraulic jack, do not bear upon the question, as we have in all such cases a concentration of the power, it is true, but no accumulation.

Five points have to be considered in relation to the subject in hand, namely—(1), the cost of generating the power; (2), the loss by friction; (3), the cost of the machinery; (4), convenience of application; and (5), the cost of maintenance.

The cost of generating the power should be taken as including all expenses incurred in the prime mover and the pumps and accumulator, as the power developed by the prime mover is, till transferred to the accumulators, of no more avail than if none existed. Very erroneous statements have been put forward as to the cost of pumping into accumulators, such statements being usually based on the duty performed by pumps working at lower pressures, such as are required for work of a totally different kind. The friction in pumps working at low pressures very much exceeds in proportion that of hydraulic pumps working at high pressures, and we shall be able to show that the percentage of friction rather diminishes than increases with the pressure, even at high pressures. Further, the amount of power accumulated will increase as the differences of the squares of the diameters of the plungers, but the friction of the plungers only increases as the first power of the differences of their diameters. On this ground, pumps of large diameter and short stroke seem most desirable, but the frequent opening and closing of the valves, and the greater strength of the framing and gearing required with such increase of diameter, must be weighed in practice, and a line drawn beyond which this theory must not be pushed. The increase of friction from the increased strength of gearing cannot be stated otherwise than by a reference to each particular case, but a little consideration will make it evident that this increase bears but a small proportion to the diminution of the friction on the plungers, because the speed of the moving parts is in the inverse ratio of the squares of the diameters of the plungers, while the increase of the frictional surface will be in the direct ratio of the diameters. It may be taken roughly that the increase of friction in the gearing will be directly as the increase in the diameter of the plunger, and the diminution in the friction of the plunger in a like proportion. There is one other element of friction to be considered ere the power accumulated is available for use, namely, that due to the passage of the water through the pipes, forming the communication between the accumulator and the machines which use the power. This friction is but little increased by the length of such pipes, but is very seriously augmented by all indirect-passaged valves, sudden bends, and all alterations of the form or area of passage. Of these and other kindred points we shall speak more fully in future articles when we come to discuss the designing and making of hydraulic apparatus. Having reviewed these preliminary points, we can now pass to the consideration of the great source of economy incidental to the use of accumulated power for intermittent work, such as punching, shearing, forging by dies, bending and straightening metals, hoisting, pressing and packing, and many other processes. The chief source of economy lies in the use of a far smaller prime mover than could otherwise be used, such prime mover working against a continuous and equal load, and therefore, *cæteris paribus*, working economically. Fully to appreciate this advantage it is necessary to bear in mind, that the saving in the size of the prime mover is in direct proportion as the intervals of rest of the machines exceed their intervals of work, and is at a maximum when the work is regularly intermittent, and of the shortest duration as compared with the intervening period. It naturally follows, therefore, that heavy work requiring some time for its intermediate handling and preparation, followed by the exertion of excessive pressure through a small range, offers the most economical field for accumulated power. As the intervals of rest grow shorter the economy diminishes, but not necessarily the convenience. To make our meaning plainer, let us take the case of shearing and punching plates, requiring, say, fifty-four seconds each to place in the tools, and the application of a power for six seconds equivalent to raising 500 tons through 1.2 in. In round numbers, 34-horse power will be the power developed for six seconds. Now, supposing a water-wheel or steam engine to be the prime mover used, we should require one of 34-horse power continually at work, during only one-tenth of which time would it do any useful work; with an accumulator, on the other hand, one of 3.4-horse power would do the work. It will be seen, therefore, that we save the power absolutely lost in driving the larger engine or wheel for nine-tenths of its time, the interest on its first cost, and the extra room it would require. In each case, to a small engine or other prime-mover, pumps of equally small size will be required, but the size of the accumulator depends on other data. By the following method the proportionate sizes of each part of the hydraulic apparatus may be fixed: The work to be done in, say, one hour or one day, must be estimated; then a prime-mover must be fixed upon capable of doing this work per hour or per day, and, as before stated, the size of the prime-mover will indicate the capacity of the pumps. The capacity of the accumulator must be arrived at by estimating the duration of the longest interval of rest, and then calculating the size of the accumulator to hold the full quantity pumped during that time. After the capacity of the accumulator has been arrived at, it will be necessary to determine what length of stroke shall be adopted. This will involve important practical considerations regarding the load to be carried, and its momentum in falling when water is drawn by the machines. The power remaining the same, the pressure per inch will exercise a considerable control as the designing of the pumps and accumulator. We shall defer treating these points in detail, as our space will not, in the present article, admit of more than a general treatment. We now come to a very important point in the use of hydraulic machinery, namely, the cost of machines themselves and their size. In the first place, we note that well-designed hydraulic machinery for the various operations before mentioned is very simple in its constructive details as compared with geared machinery, is also much smaller and lighter than other machinery of equivalent power, and exhibits a much lower percentage of friction. It is also a fact that as the power is increased, these three advantages of simplicity, lightness, and small frictional cœfficients, become more and more marked as compared with other contrivances of corresponding power. Of course, cost in machinery is considerably dependent on simplicity of parts, and it will be found that in all cases where hydraulic machines have been properly designed and made, the first cost and the cost of maintenance have been small, compared with other machinery of equal capacity. The chief item of expense in the maintenance of hydraulic machinery lies in the cost of renewing the cupped leathers; and from want of a little good bainwork in the design of the machine, the cost of putting in the latter is often far more than the cost of the leather itself—in fact, it is the writer's experience that this is the rule rather than the exception. It is also very noticeable in most cases that the leathers do not have a fair chance of a long "life" by reason of the inferiority of the surface against which they work, arising from "specks" and deficiency of finish. It is very difficult, nay, even impossible, to get a perfectly clear surface on cast or wrought iron by ordinary tools and operations; but much may be done by the adoption of little practical "dodges," of which we shall have occasion to speak hereafter. The consideration of the convenience of hydraulic machinery opens up a very wide and interesting field of applied mechanics; but one rather difficult to treat of generally, as each individual case offers some distinctive features of its own. Yet we can select certain salient features which may serve as mental standpoints from which to regard isolated cases, which may arise in each branch of manufacture. In all cases where it is a necessary part of a process to have a machine to stand for accurate adjustment of the work, as in punching, shearing, etc., accumulated hydraulic power is very advantageous, as the tools can be brought close to the work and kept at any point quite steady till the adjustment is complete, when the blow can instantly be obtained. There is also the very great advantage that the pressure can be kept equally on the work, aud will follow it up self-acting, which other gearing will not do satisfactorily. There is one point of superiority in hydraulic pressure from an accumulator which in many operations is eminently important, and which is equally characteristic of it, and that is, that if the "work" will not yield, there is not an increase of pressure, as in other cases, and therefore no risk of such an increase of strain as to break the machine. No doubt many of our readers have seen numerous cases, in machines which possess momentum and have to pass a dead center, of ruinous fractures, due to some impediment which has got in and tended to stop the machine. In such a case there is an instantaneous conversion of the *vis viva* of the machine into a force which often becomes disruptive. As an instance, the fractures of screw-heading machines may be taken; nor are such instances uncommon in ordinary shearing machines. There is no remedy for this difficulty other than to adjust the strength of the machine so as to be capable of suddenly absorbing the *vis viva* of its own moving parts. This, however, cannot always be done. Hydraulic machines, on the other hand, require only to be constructed capable of bearing the normal strain of the work, as such strain cannot, in the very nature of the case, become abnormal. In all cases where a large power is required to be put on a small area, hydraulic power offers great advantages, as small, accessible, and easily controllable tools of immense power can thus be obtained; but in some cases peculiarities in the work modify these advantages so far as to preclude this successful application, as for instance, where it is imperative to have a long traverse with very little work except at the end of the stroke. In such a case the great waste of power would preclude such an arrangement, except in cases where convenience was a paramount question and power of little value. It is in dealing successfully with such questions of suitability that the engineer can show his grasp of his profession, and on such fields do the masters of the credit meet and overthrow the mere charlatans and men of a "groove."

EXPLOSIONS OF NITRO-GLYCERINE.

From "The Engineer."

After referring to the late disaster in Wales, our authority proceeds as follows: Our object is not now to discuss the unfruitful question of what brought about this disaster, as its proximate and immediate cause, but to offer a few practical remarks with a view to prevent the recurrence of others, based on a somewhat more precise knowledge of the properties of the substances concerned than appears possessed by the "correspondents" of our various contemporaries, or by anything brought before the "crowner."

Since the introduction of nitro-glycerine to practical use, at least half a dozen tremendous explosions of it have taken place in Great Britain, several in America, and a few in Germany and France. Their effects in destroying life—with circumstances as sudden and inevitable, and more appalling than death by lightning—have filled the imagination of all who have listened to or read accounts of them with inexpressible dread of this tremendous agent; and it is quite likely that at the motion of some of our legislative wise men—of the kidney of those who would abolish patents because they hamper some people and tend to produce lawsuits—some attempt will be made to interdict the use of nitro-glycerine as a blasting agent in our country; or so to restrict the conditions for its storage and transport as to diminish, or even neutralize, its enormous advantages to the quarryman, the miner, and the tunnel-driver.

We do not for a moment contend that some legal and police regulations as to its manipulation in storage and transport are not most desirable; on the contrary, we say at once, the necessary powers for *codifying* and rendering such stringently operative ought to be taken, and immediately applied. But let us first clearly ascertain what such regulations should consist in, and how far they need go.

If nitro-glycerine, like tri-nitro-cellulose or gun-cotton, be badly prepared—we shall not here go into any chemical particulars—it may pass into a state of incipient decomposition, and of chemical condition so unstable as to explode—as we may popularly, but still not with philosophic accuracy express it—spontaneously.

Against this the only real safeguard must be the skill, fidelity, and reputation of the manufacturer; and were proper means taken to prevent extraneous and other causes of explosion, the makers of nitro-glycerine would see that it was to their own interest to send out nothing but such as was, in this respect at least, safe. In fact, we have no doubt that, as far as any tendency to explosion of this sort goes, as much may be done for nitro-glycerine as Mr. Abel—following after Von Lenck and others—has done for gun-cotton, which once had, and somewhat justly, a bad character in this respect.

But, secondly, let us ask, on behalf of nitro-glycerine, is it to be supposed that more than seven hundred years ago—when gunpowder first began to be practically employed as an explosive agaent—that there were not many and terrible so-called accidents attending its use? Such must be the course of events with any new and powerful agent suddenly brought into popular handling; and such must equally tend to disappear as popular ignorance gradually gives way to rapidly diffused information as to the properties of the newly-acquired agent. Well, what remains, then? That we can and ought so to guard against, as serpents, the properties of this new agent, so enormously more powerful when exploded—and as exploding by concussion, so unquestionably more dangerous than gunpowder.

To say in sufficient detail all we could say, and at the proper place, should be prepared to say on this, would far outstep the limits of a leading article, but it may be all condensed into one general sentence—so store and so transport your nitro-glycerine that concussion or percussion, internal or external, shall become physically impossible, and so that no violent or extreme change of temperature, above or *below* a fixed mean, shall occur; effect that, and future danger or "accident" will, to a great extent, vanish.

It seems but little generally known that the wonderful, and even yet little understood rapid inversion of chemical forces called explosion, tends to propagate itself, by mere shock perhaps, from one isolated mass to another. The facts observed as to the successive blowing up of more or less distant buildings in powder mills, when one only has been first exploded, shows that this is true even of gunpowder, an agent which is with great difficulty, and only under certain circumstances, caused to explode by percussion, as Faraday long ago showed. But it is eminently true of fulminates properly so called, of which nitro-glycerine is one; for though explodable either by sufficient ignition or heating, it is far more readily so by any violent shock, or by a blow from a hard body, or from even a gas evolved at great velocity, as from a percussion cap.

When Mr. Hennel, the operative chemist at Apothecaries Hall, London, was blown to atoms many years ago by the explosion of a large copper dishful of fulminate of mercury, holding several pounds, beside which at a distance of several feet he was standing, the explosion of the whole appeared to have been induced by the slight but sharp impulse given through the air, by the explosion of a grain or two of the fulminate which he incautiously took out and exploded by a blow of a hammer to judge of the quality of the mass itself.

Mere subdivision of nitro-glycerine into small parcels—these being placed tolerably adjacent or in the same building—will be nugatory as any safeguard that one portion only may explode and leave the others untouched.

Roughly we may say that unless the distance between the stored separate masses be such, or the interposed divisions—such as heavy walls, vault arches, or the like—be so massive that the shock or sound of the explosion of one mass shall be imperceptible at any one of the others, mere subdivision can afford no certain security that when one goes all shall go off in succession. But there is another circumstance to be taken into account—the effects. Now, the leveling agency and life-destroying power of nitro-glycerine are so great, and so much in excess of gunpowder, that subdivision ought to be insisted on, and we hold it that the law should provide:

1. That no nitro-glycerine should be stored at all, except in places not less than half a mile from any inhabited house or factory, or other usual resort of large numbers of employed persons.

2. That public stores should be provided for it, to which it should be removed from ship or railway on the night after its arrival, and only at night.

3. That not more than 500 lbs. should be stored any-where in one mass, and to that extent only in public magazines.

4. That transport through public thoroughfares should only be done on license given, after written notice to a public officer (probably of the customs or excise), and then accompanied by a subordinate appointed by that officer.

5. That all private consumers should be obliged to provide magazines, to the approval of a recognized authority; and that these be on the same principle of distant subdivision and position as to human habitations, etc., as the public magazines; and that the maximum stock in any one mass should not exceed such quantity less than 500 lbs., as such authority should sanction.

These regulations would really impose no serious burden or restriction to use, and, so far, would be pretty effectual.

There remains, then, the mode of package and transport; and here there is immense present recklessness, and room for an immense improvement. Soldered zinc or tin-plate or galvanized iron bung-stopped cans are about as dangerous as any vessels can be. Leakage can scarcely be avoided at the bung—a screwed stopper is still worse—the chance of leakage is great, and a fragment of flint, or grit, or glass, or of any hard body, in extracting or replacing it, may cause explosion. The soldering is often staunch at first, simply by reason of a film of *rosin* at an imperfect place; and when this dissolves or is rubbed away leakage occurs; and if some of the leaked liquid be exploded, though outside and some feet, perhaps, from the can, the whole may explode. But there is a further and more insidious cause of danger. Many such cans have bits of loose solder accidentally included in them, or bits that may become loose. These are necessarily tail-like bits, with sharp points and of angular forms. These, if shaken about in the can, may induce explosion, as may a bit of wire, or an iron prong or broken corkscrew, or any sharp and hard solid if dropped into the can, and afterwards shaken about in it. In fact, just as a needle thrust into a glass of still soda-water or a few angular crumbs thrown into a glass of dead champagne will re-establish effervescence, so is the instability of already unstable chemical compounds increased, and if explosive, their tendency to explode. Even rough points, or lines, or seams, and far more, sharp corners or re-entering angles in the inside of vessels have the same effect, of which many remarkable examples have been noticed and recorded, both as regards combination and decomposition, by Chevreul, Becquerel, Mallet, and others. But we must be brief. We say, therefore, that in place of these cans the only vessels permitted for transport and storage of nitro-glycerine should be strong ellipsoidal metallic bottles, something the shape of a soda water bottle but of larger diameter in proportion to length, and each made out of one sheet of metal without solder or seam, by the method of hydraulic pressure in suitable moulds, which was exhibited, in 1867, in the French department, and examples of its marvelous facility and adaptability to any form or size there shown.

These vessels should be strong enough to resist dinges or dents by any moderate blow or by being let fall from a man's hands, and should be perfectly smooth within. The neck should be wide enough to enable the whole inside to be examined by the aid of a properly projected and powerful illumination, and it should be closed neither by bung nor ground valve, nor screw cap, nor by anything capable of producing rubbing, friction or catching up grit, or requiring force and iron instruments to extract—but instead by a flat plate having a ring of gutta percha or cork, or other more suitable and slightly compressible material inserted flush in a circular sunk race, and made to bear against the flat edge of the neck of the vessel. This plate or valve should be pressed tight into place, and held there by a screw bearing upon its outer surface, and passing through a ∩-shaped bridge, hooked on to two lugs, formed outside the neck of the bottle. Each such bottle should be packed into a sheet iron cylindrical canister with a cap, and at least 2-in. or 3-in. of dry elastic sawdust intervening all round it, and each such packed canister should be enveloped always in a thick mat of "gunny bagging," or other cheap elastic material.

We cannot extend here further, though much more remains that we should like to add. However, were even the precautions, which we have here rapidly sketched, taken, and zealously, and not in laziness and official sham, but really carried out, we venture to affirm that a considerably increased length of time would be found to elapse before the next blow-up of nitro-glycerine should occur; and whenever it should we would hope that the coroner's jury verdict would not be, as at Carnarvon, one of "accidental death."

SHRAPNELL *v.* SEGMENT SHELL.

From the London "Times."

There are three distinct parties in this controversy. First, the out-and-out Segmentite, who considers shrapnel a thing of the past, and has not the slightest faith in it either as a shell or a shot; second, the rabid Shrapnelite, who looks upon his favorite projectile with the fluttering affection with which a hen regards her one chicken; and considers that segment shell violates every condition of scientific and practical gunnery, and is utterly inadmissible in consequence; third, the dispassionate party, who are platonic enough to view the contest with unruffled equanimity, and whose chief object is to get the best thing they can for the service, irrespective of the fact that it is the invention of Boxer or Armstrong. Let us see, now, what these several cliques have to say for themselves.

The Segmentite usually affects to be eminently practical; he disbelieves in the efficient boring of time fuses in action, ridicules the firing of such projectiles under most of the circumstances met with in actual war, and calls the rifled shrapnel a wooden-headed piece of complication. It is absurd, he urges, to suppose that future battles will be fought over ground selected expressly to develop the merits of shrapnel fire. Troops will be more or less protected, the soldier will instinctively seek cover, and the very key of the position on many a battle field may be a rude house and garden, with a few hastily thrown up entrenchments, against which the fire of shrapnel would be entirely thrown away. What would be the position of a general under such circumstances if provided with a shrapnel alone? Must he wait for his siege train before he could attack a farm-house? With what projectile are we to attack stockades, abattis, houses, villages, woods, field earthworks, and war material such as guns, carriages, and wagons? Are horse artillery when acting with cavalry in pursuit of an enemy to be obliged to bore and fix fuses in the hurry and excitement of action, when time is of the greatest possible consequence? Is the No. 1 supposed to ride with his pockets full of fuses, and the gimlet in his mouth? Suppose the man with the bradawl is killed, who is then to "look for the needle in the bundle of straw?" The segment shell can be fitted with a concussion fuse and carried into action ready loaded. No boring and fixing of fuses is necessary. The gun may be served as quickly as with shot; the burst on graze facilitates the estimation of distance, and a few turns of the elevating screw is all that is required. Look at the simplification of drill under these circumstances. The soldier has nothing to look for but the cartridge and shot; he may be the veriest tyro, and still be an efficient gunner. The use of time fuses, on the contrary, necessitates careful drilling. A man whose fingers are all thumbs from the cold of Canada would make a sorry exhibition in boring a time fuse, particularly if he had only been partially instructed, and in case of war there is little or no time in which to instruct the recruits sent out hurriedly to replace casualties in the ranks. Such we may suppose to be the chief arguments advanced by the out-and-out Segmentite.

To him the rabid Shrapnelite replies: The shrapnel shell is constructed on true principles, which cannot be said for the segment. Such a fire is more independent of a correct knowledge of range and configuration of ground than any other. It is manifest that it matters not to the shrapnel shell, bursting as it does in the air, whether the ground be hard or soft, smooth or broken, undulating or flat. The action of the concussion segment depends, on the contrary, on the nature of the particular spot struck. If that be the side of a hill, the projectile enters the ground, and the effect is merely a shower of earth; if it be a soft morass, the shot buries itself in the spongy ground. To obtain good results from segments it is necessary to burst the shell close to the object, and there is a greater chance or probability of oversight in the correct elevation of the gun than there is in the true boring of a fuse where a certain limit of error is admissible. The velocity, again, of the segments will be materially diminished by the shell striking the ground, and the comparative effects will be less than in the case of a projectile bursting in the air unchecked. The spherical bullets of the shrapnel meet with much less resistance from the air than the irregularly formed segments. The fire of shrapnel is much more formidable than segment against troops in the open field, either as skirmishers or in line, and although segment shell may under certain circumstances have a seeming advantage, the result is generally to be attributed to accident. Troops under cover must be dislodged by special means; common shells must be "lobbed" so as to render their retreats untenable. All such defenses as pahs, stockades, abattis, earthworks, etc., must be attacked by common in conjunction with shrapnel shell. The boring and fixing of fuses is a mere matter of drill; in the old smooth-bore days no difficulty was experienced, and there is no evidence to prove that the race of gunners has degenerated, or that we have now less of the coolness and intrepidity for which the regiment has ever been justly celebrated. This soldier-like quality is assuredly present amongst us to-day as formerly. There is no reason why, with an efficient system of drill, shrapnel shell should not be fired just as quickly as shot. It is an error to suppose that heavy infantry or cavalry columns will be massed on future battle-fields; on the contrary, the troops are more likely to be moved in open order, and with an extended formation, to enable them to use with greater effect the improved weapons of the present day. We shall have shallow formations combined with a rapid system of light infantry drill. Against such an order of battle the fire of shrapnel will tell with deadly effect. On the other hand, if concussion fuses are found to be most effective against troops in column, there is nothing to prevent their use with shrapnel shell.

Having heard the arguments on both sides, the moderate party may be supposed to draw the following conclusions: Shrapnel shell, when served with deliberation, is, doubtless more effective than segment shell under certain conditions. On the other hand, the segment shell fitted with a concussion fuse is always ready to hand, and is certainly more simple and decidedly cheaper than shrapnel. Probably two segment shells, with a simple concussion fuse, could be bought at the price of one shrapnel. Again, segment shells, when fired with concussion fuses, have proved themselves very formidable projectiles against abattis, guns, stockades, and troops under the cover of low walls and breastworks. It is very improbable that the leaden bullets of the shrapnel would have much effect in cutting to pieces the wheels of gun carriages or the struts of a stockade. We have fired segment shells with concussion fuses in real warfare, and all the officers who have used them, or witnessed their use, speak most highly in their praise. It is notorious that both the Russians and Prussians look on shrapnel shells with disfavor; even the Austrians, who use a pattern almost identical with our own, are said to have considerably reduced the proportion of shrapnel carried by their field batteries. Now, this course has been adopted, not from the results of a fire against inanimate two-inch wooden planks, but against warm flesh and blood; and, although we may have our insular prejudices on following or regarding the opinion of foreigners, we should proceed with due caution and do nothing hastily. The Boxer shrapnel is an admirable projectile, and we are justly proud of the inventor, but will it satisfy all the requirements of service? If we adopt an exclusive employment of shrapnel, are we right, and all the rest of the world wrong? On the other hand, suppose both are right, would it not be advisable to have some of both projectiles? No doubt by adopting this course we shall please neither the thorough going Segmentite nor the rabid Sprapnelite; but what then? We have no personal interest in either Sir Wm. Armstrong or Colonel Boxer beyond a sincere admiration for the talents of both. Our object is to adopt the best projectile we can for the service, irrespective of its maker. Which would it be best to have—shrapnel, common shell and case; or shrapnel, segment shell and case?

LONDON STREET RAILWAYS.

From a paper before the Inventors Institute by Mr. Thos. Measam, A. I. C. E.

After mentioning the successful attempts of Mr. Train and others to establish street railways in London, and describing the routes of the three roads now projected, in all $6\frac{1}{2}$ miles of double and $6\frac{5}{8}$ miles of single line, the author says: The early tramways appear to have been constructed in the following manner: Cross sleepers of timber, some 6 ft. long, and varying from 6 in. to 8 in. square, were fastened, by treenails or other means, 4 ft. apart. Upon these planks two wrought-iron angle-plates, about 4 in. wide, and $1\frac{1}{4}$ in. thick, were firmly secured. This construction evidently affords all the mechanical advantages that are derived from tramways of more recent date. The tramways laid down by Mr. Train, in 1861, in London and elsewhere, and which were similar in construction to the most improved trams then in use, and which continue largely to be in use in some of the principal cities of the United States, consisted of two wrought-iron plates, each 5 in. wide, weighing 50 lbs. to the yard, and bent at near the center to a depth of $\frac{3}{4}$ in. below the general level of the road. These plates were fixed to longitudinal timbers, embedded on concrete, and the gauge of the line was that of ordinary railways—4 ft. $8\frac{1}{2}$ in. These trams proved dangerous and obstructive. The construction of the improved tramways now proposed is as follows: For single lines of tramway, two flat wrought-iron plates, each $3\frac{1}{2}$ in. wide, weighing 40 lbs. to the yard, with an indented channel $1\frac{1}{8}$ in. wide, and $\frac{3}{4}$ in. deep, placed on one side of the center line of the plates, are to be fixed by bolts, or otherwise, to longitudinal timbers of the width of the plates placed at such distances apart as to give 4 ft. $8\frac{1}{2}$ in. for the gauge of the line. The timbers are to be embedded in concrete 9 in. deep, and are to be of 6 in. or 9 in. in depth, according to the size of the pitching used for the roadway. Tie-bars of thin wrought-iron, connecting the longitudinal timbers, are proposed to be placed at intervals of 4 ft. The space between and on either side of the tramways is to be paved with granite pitching. In the case of double lines, the intermediate way between the trams is to be 4 ft. wide, and the whole space from 11 in. on either side the outside rails, equal to 17 ft. is to be paved the entire width. In other respects the double line is of identical construction with the single tramway. The estimated cost for the paved single tramway is £6,000 per mile, and for the double tramway £12,500 per mile. Another form of rail (known as the "crescent rail") has been used for tramways to a limited extent, but it is considered much inferior to the rail before described, and is not likely to be much adopted. It consists of a curved plate of wrought-iron about $2\frac{1}{2}$ in. wide, and weighs 24 lbs. to the yard.—The grooves for the flanges of the wheels are partly formed by the granite pitching, which cannot but be considered a very imperfect contrivance. In the American system of tramways the longitudinal timbers are tied together by 4 in. planks instead of with iron bars, the planks being placed under the longitudinal timbers. In other respects the American tramways vary but little in construction from the tramway described. The rails first used were similar in form to Train's rail, and were now in a great measure superseded by the improved rail. The carriages proposed by the London tramways are to weigh 33 cwt. The length of the body of the carriage is to be 16 ft.; the width over all, 6 ft. 8 in. They are to carry fifty passengers, and are to be so constructed as to give 1 ft. greater space between the seats than is given by the omnibuses now in use. The maximum rate of fare is to be one penny per mile for distances above three miles, and 3d. is to be the least fare. The rate of traveling, including stoppages, is to be six miles per hour.

Tramways, said Mr. Measam, would doubtless give easier traveling and more commodious conveyances than are to be obtained at present, but here—excepting that the tramway companies are to maintain a portion of the public roadway over which they pass—the advantages of tramways seem to cease. It is surmised that a line of carriages passing to and fro every three or four minutes in one undeviating line, claiming priority of way, and scattering the general traffic, cannot but be productive of annoyances, to say nothing of the obstacles which the rails may cause. It is much to be doubted, Mr. Measam thought, whether all the disadvantages resulting from Train's tramway were alone due to the rail used by him—which, it must be remembered, had been in use for some time in the United States—or whether they were not, in a great measure, inseparable from the working of the tramways on a roadway of mixed traffic. Further objections to the introduction of tramways start up in the form of difficulties put in the way of connecting houses in their line of route with the gas and water mains and with the sewers. But the chief objection to street tramways as proposed to be introduced seems to be, that individuals acquire privileges and rights in the public highways not possessed by the community at large, and that the public property is appropriated for the use and trading purposes of private speculators. Although some strong measure was necessary to destroy the existing monopoly in metropolitan street passenger conveyance, to bring this about by so great an interference with the public rights as the permitting of individuals to construct permanent works on the public highways, is a remedy likely to produce worse evils than those it is intended to remove.

There is another consideration in favor of tramways, however, and that is the reduction of friction resulting from their use. On a good paved road the force of traction is about 24 lbs. for every ton weight of carriage, including, of course, the load. On a tramway it may be taken at 8 lbs. per ton, giving a mechanical advantage to the tramway on level surfaces of 3 to 1. On inclines the advantage rapidly decreases, and on a gradient of 1 in 26 (which it is believed, is the steepest incline there is on the proposed metropolitan tramways) the difference of the force of traction on a tramway as compared with a paved road is only as 117 to 100. Practically, it may be considered that a horse on a tramway will do the work of two horses on an ordinary road. The practical advantage of street tramways, therefore, seems to resolve itself into the fact that the same amount of traffic can be conducted at one half the expenditure of horse power necessary on an ordinary road. This advantage is purchased at the cost of the construction of the tramways, and the maintenance of a large portion of the highways. The estimated cost of the tramway from Whitechapel to Stratford is £45,000, excluding coach-houses, stabling, etc. The annual expense of maintaining the highway the company is bound to keep in repair, assuming the cost at one shilling per yard, would be about £1,600. On the other hand, assuming 120 horses to be the number required for conducting the traffic, there would be a set-off against the above specified expenditure of the value of this number of horses. Considering that commodious carriages are not necessarily restricted to the railway system, the omnibus proprietors need not much fear the rivalry of the tramway companies. That tramways are the best suited for omnibus traffic none but omnibus proprietors would deny, and if a portion of the public roads is to be set aside for omnibus traffic, no better mode of conducting it than by tramways could be devised; but considering the different kinds and the large amount of traffic that has to be accommodated, and the various uses to which the public roads are necessarily applied, Mr. Measam considered it would be more generally advantageous to restrict the construction of tramways, as has hitherto been the rule, to such roads as their promoters have an exclusive right to use.

In the discussion which followed the reading of the paper, the chairman said that with regard to the metropolis, tramways were unsuited to the wants of the traffic at large, although they might advantageously be adopted in such wide thoroughfares as were to be found on the Surrey side. In Cheapside trams would be out of the question. He was practically acquainted with the working of Train's tramway, however, and he was bound to say that there was not the slightest ground for saying that any accident was caused by the projection ($\frac{3}{4}$ of an inch) of his rails. There was no such thing as the breaking of good axles by going over the rails, but four or five people were specially paid to take broken-down carriages with bad axles and bad springs, and drive them over and over the rails until they inevitably had a "smash." There was no mechanical difficulty in the way of making tramways succeed, but the Legislature would (the chairman thought) be better advised if they gave powers to make increased thoroughfare accommodation rather than to construct tramways. Mr. G. W. Reid, from America, said that on that continent there were 10,000 or 15,000 miles of tramway at the present time. In Boston, a city built on exactly the same model as London, with narrow winding streets, tramways were laid in all the principal streets, and worked with perfect success in thoroughfares not wider than our own misnamed Broad-street City, and there was not one street in Boston in which the trams were laid down wider than Cheapside. Where the streets ran parallel and contiguous to each other, the "up" line was carried along one street, and the "down" line along another. Mr. Greaves, as engineer to one of the schemes just sanctioned by the select committee, adverted to the excessive cost entailed in getting private bills for public works through Parliament, and said that (seeing that tramways were undoubtedly public boons) he did not see why vestries and local boards should not lay down these trams. They had the power to pave the roads in what manner they pleased; then why not make a portion of the paving to consist of iron trams with grooves in them?

STEAM ENGINE PERFORMANCE.

Messrs. Farey and Donkin have recently made some remarkably thorough and comprehensive experiments in this direction, which are quoted and discussed in the London papers. The following are the particulars and the comments of "Engineering":

Experiments by Mr. Farey and Mr. B. Donkin, jun., upon a Double-Cylinder Jacketed Condensing-beam Steam Engine of 30-horse power nominal, constructed by Messrs. B. Donkin and Co., Bermondsey, London.

Dimensions of engine.	Diameter of cylinders 24 in. and $13\frac{3}{16}$ in., having strokes respectively 4 ft. 6 in. and 3 ft. $3\frac{3}{8}$ in.	Stroke of crank 4 ft. 6 in.

Indicated horse-power, taken with four indicators, diagram taken every half hour, work very constant.....	46.21 HP.
Pressure of steam in boiler house by mercurial gauge, taken every half hour, kept very constant, mean...	40.9 lbs.
Pressure of steam in engine house taken every half hour, mean......	$40\frac{1}{2}$ lbs.
Duration of experiment..............	10 hours.
Revolutions of engine per minute, by counter, mean speed.............	32.48 rev.
Vacuum in condenser by mercurial gauge, mean.....................	27 in.

Condensing water. The temperature and quantity were taken constantly by a self-acting recording photographic apparatus, as described in "Engineering," July 17, 1868.	Temperature.	Going in from a deep artesian well quite constant	53°
		Coming out, taken photographically mean.	89.54°
		Degrees of heat put into condensing water or rise.	36.54°
	Quantity.	Quantity of water per min., measured over a tumbling bay 6 in. wide, height recorded photographically,	408.32 lbs.
	Pound-degrees.	Lb.-degrees per min., or units of heat 408.32 lbs.×36.54°	14,920 lbs.
		Lb.-degrees per min. per indicated horse-power $\frac{14,920}{46.21}$......	322.87 lbs.

Water from Steam jackets.	Temperature.	Taken every quarter hour, hour, mean............	207°
	Quantity (from a steam trap).	Total pounds accurately weighed...............	$1,783\frac{1}{2}$ lbs.
		Pounds per minute......	2.97 lbs.
Feed water taken from Water Company.	Temperature.	Taken every ten minutes, mean.	$74\frac{1}{2}$°
	Quantity.	Total water evaporated in pounds	$10,404\frac{1}{2}$ lbs.
		Pounds per hour..........	1,040.4 lbs.
		Pounds per minute	17.34 lbs.

Description of boiler; vertical tubular.

Total quantity of coals burnt, accurately weighed (quality of coals—Welsh, but very inferior, great deal of dirt, shales, cinders, and clinkers	1,204 lbs.
Pounds water per pound coal burnt, or efficiency of boiler with this coal..	8.72 lbs.
Pounds coal per I.HP. per hour.......	2.61 lbs.
Pounds water evaporated from temperature of $74\frac{1}{2}$° per I.HP. per hour	22.51 lbs.
Expansion with steam cut-off at about $\frac{7}{16}$th stroke in small cylinder, allowing for passages and clearances, about..........................	11 to 1
Number of indicator diagrams taken, four always taken simultaneously, two at top and two at bottom of the two cylinders.	84
Temperature of outer air, fine day	67°
Temperature of steam-engine house, mean.	76°
Height of barometer	30 in.

Tallowed cylinders twice, $1\frac{1}{2}$ pints tallow used, also 1 pint of oil for all other parts.

This same steam engine indicated, when running empty, including cold water pump, was found to take $3\frac{1}{4}$ indicated horse-power.

Other experiments on this engine gave a result of about 300 pound-degrees at $\frac{1}{4}$th cut-off in the high pressure cylinder, instead of 323 pound-degrees at $\frac{7}{16}$ths.

In this experiment the vertical boiler evaporated only 8.72 lbs. water per pound of inferior Welsh coal, but in other experiments on the evaporative power of this boiler, when using a better quality of Welsh coal, and evaporating double the quantity of water in the same time, the result was 10.01 *lbs. water per pound coal*, with feed water at 61° temperature. Had this been the case in the above experiment, the quantity of coal consumed would have been $2\frac{1}{4}$ *lbs. of coal per indicated horse power per hour*.

The trial was conducted throughout with great care, four engineers being employed to take indicator diagrams simultaneously from the upper and lower ends of the two cylinders every half hour; while a fifth engineer checked the registration of the photographic apparatus by noting every quarter of the hour the rate of flow and temperature of the water from the hot well. A sixth engineer observed the boiler pressure, and kept account of the weight of coal used; while a seventh measured the quantity and temperature of the feed-water, and an eighth recorded the quantity and temperature of the water drawn from the steam jacket.

The results above recorded are of great interest, and by analyzing them we shall be enabled to show approximately the manner in which the heat generated by the combustion of the fuel is disposed of. In the first place we may assume that, as the coal was of inferior quality, it would not, on an average, be capable of yielding more than about 13,500 units or pound-degrees of heat per pound consumed; and as the rate of consumption was almost exactly 2 lbs. per min., we may fairly take 27,000 units of heat per minute as the gross quantity of heat theoretically available. The quantity of water evaporated per minute is given as 17.34 lbs., this water being converted into steam at a pressure of 40.9 lbs. above the atmosphere. The total heat of steam at this pressure is 1,201.6, or, say, $1,201\frac{1}{2}°$, and as the feed-water was supplied at a temperature of $74\frac{1}{2}°$, each pound of water in being converted into steam would absorb $1,201\frac{1}{2}-74\frac{1}{2}=1,127$ units of heat; and the total amount of heat thus absorbed per minute would be $1,127\times17.34=19,542.18$, or, say, 19,542 units. Again, if we assume 24 pounds of waste gases to be evolved from the furnace per pound of fuel burnt, and further assume that the specific heat of these gases is .24, and that they were discharged into the chimney at a temperature of 400° above that at which the air was supplied to the fire (all fair assumptions), we get $2\times24\times.24\times400=4,608$ units as the quantity of heat carried off per minute by the waste gases. We can thus approximately account for the heat generated per minute by the combustion of the coals, as follows:

	Thermal units.
Heat absorbed by the generation of steam,	19,542
Heat carried off by waste gases..........	4,608
Heat lost by radiation, imperfect combustion, etc..............................	2,850
Total	27,000

Of the 17.34 lbs. of steam produced per minute, 2.97 lbs. were condensed in the steam jacket and discharged as water at a temperature of 207°. Of the steam thus condensed in the jacket, each pound thus gave up $1,201.6°-207°=994.6$ units of heat, and multiplying this number by 2.97 we get 2,953.962, or, say, 2,954 as the number of units of heat per minute given up by the steam jacket. The weight of steam admitted into the cylinders of the engine (supposing no condensation to have taken place on the way from the boiler) would be $17.34-2.97=14.37$ lbs. per minute, and as the steam was ultimately discharged into the hot-well as water, at a temperature of 89.54°, each pound must have had abstracted from it on its way through the engine $1,201.6-89.54=1,112.06$, or, say, 1,112 units of heat. We thus have $14.37\times1,112=15,979.44$, or, say, 15,979 units as the quantity of heat given out per minute by the steam during its passage through the engine, and adding to this the 2,954 units given up by the steam jacket, we have a total quantity of 18,933 units per minute to be accounted for.

It will be noticed that the quantity of heat just mentioned is less by 609 units than that absorbed in the generation of steam, this deficit being caused by the water being drawn off from the steam jacket and discharged from the hot-well at higher temperatures than it is supplied to the boiler. Thus the 2.97 lbs. of water withdrawn from the steam jacket had a temperature of 207°, or $207-74\frac{1}{2}=132\frac{1}{2}°$ higher than that of the feed; and $2.97\times132.5=393.525$, or, say, $393\frac{1}{2}$ units are thus accounted for. Again, the condensed steam in the hot-well had a temperature of 89.54°, or 15.04° higher than that of the feed, and multiplying this by the weight of steam passing into the hot-well per minute, we get $15.04\times14.37=216.1248$, or, say, 216 units thus disposed of, a quantity which, added to the $393\frac{1}{2}$ units above accounted for, gives $216+393\frac{1}{2}=609\frac{1}{2}$ units, or half an unit more than the deficit above mentioned. The discrepancy of half unit is of course due to the decimal parts of an unit being neglected in our former calculations.

To return now to the 18,933 units of heat per minute, which have to be accounted for. In the first place, as the engine was developing 46.21 horse-power, $46.21\times33,000=1,524,930$ foot-pounds of work were being performed per minute, and dividing this number by 772 (Joule's equivalent), we get 1,975 as the number of pound-degrees or units of heat transformed into work. Next, it will be seen, on reference to the report of the experiments, that 408.32 lbs. of water were discharged from the hot-well per min., and subtracting from this quantity the 14.37 lbs., resulting from the condensation of the steam passed through the engine, we get 393.95 lbs. as the actual quantity of water which was raised in temperature 36.54°; and $393.95 \times 36.54 = 14,394.933$, or, say, 14,395 units of heat per minute are thus accounted for. We may thus say that the 18,933 units of heat per minute were disposed of as follows:

	Thermal units.
Converted into work	1,975
Imparted to condensing water	14,395
Lost by radiation, etc	2,563
Total	18,933

The summary is a very striking one. It shows that even in an engine of thoroughly good design and workmanship, working with what is considered a very low consumption of fuel, but about 10.4 per cent of the total amount of heat parted with by the steam is converted into useful work, whilst rather over 76 per cent is imparted to the condensing water, and about $13\frac{1}{2}$ per cent lost from radiation and other causes.

TEST OF AGRICULTURAL STEAM ENGINES.

A correspondent of "Engineering," under the head of "Steam Cultivation and R. A. S. E. Prizes," writes as follows:

That steam cultivation is approaching success, no one who has watched the various phases it has passed through can doubt, but up to the present moment it can scarcely be called triumphant, and the reason seems to me simple. Horse work upon a farm consists not merely of ploughing and cultivating, but also of a vast amount of cartage in drawing out manure, bringing home crops, taking produce to market, and bringing back lime and other artificial manures from the railway station. Now until a steam engine is able to do the heavy part of this work, in addition to ploughing, none but large and wealthy farmers or rich amateurs will be able to enjoy the luxury and the benefit of a steam plough. For a steam engine to be a thoroughly economical farm implement, it must, in fact, be able to exercise economically three distinct functions.

1. It must be suitable to drive thrashing and other farm machinery.

2. It must be able to plow and cultivate efficiently.

3. It must be a good and handy traction engine, able to draw heavy weights along the roads, and to haul out manure during dry and frosty weather, to suitable central positions on the farm.

But up to the present time we have no engine that will perform these three things economically. We have engines that will do two of them, but none that will do all three. Aveling and Porter make a very efficient although heavy traction engine, which will also drive farm machinery, but they are non-plussed when they come to ploughing. Fowler and Co., Garrett and Sons, and Howard & Co., make good enough ploughing engines, which will also drive ordinary farm machinery, but they are beaten when they attempt to work as economical traction engines.

The Royal Agricultural Society of England must move onwards, by offering a premium for an engine which shall subserve all three purposes. But unless the conditions on which the award is to be made be very carefully considered, the object will not be attained.

It must be evident to any one that the prime cost of the machinery is a very material element, but unless some data are given to fix the cost, an unscrupulous maker may call his engine such a power and at such a price, and when he comes to supply others, may give a totally different machine. Heretofore it has been the custom to talk of engines as being so many horse power, but when one comes to ask what this horse power is gauged by, we are generally told that the size of the cylinder is the criterion. Now there could not be a more fallacious guide. An 11-in. cylinder is usually called a 12-horse engine, and by the best makers that size of cylinder will be put on to a boiler having 240 square ft. of heating surface, and will be called a 12-horse engine, for the best makers allow about 20 square feet of heating surface for each nominal horse power. Again an 8-in. cylinder is usually called a 6-horse engine, being about half the area of the 11-in. cylinder, and if both cylinders work at the same speed, no doubt the large cylinder will do about twice as much work as the small one. But suppose we put an 8-in. cylinder on to a 12-horse boiler (240 square ft. of heating surface), and drive it *twice as fast, the small cylinder will then do rather more work than the large cylinder.* Would it not be folly, then, to call that engine a 6-horse engine, simply because we had changed the cylinder? But it may be said, why not drive the large cylinder fast also? The reply is very simple: the boiler would be unable to supply it with steam because a certain area of heating surface will only evaporate a certain quantity of water economically.

It is plain, then, that the heating surface in the boiler is the true test of the power of an engine, and if it be agreed by all that 20 square ft. of heating surface shall be denominated 1-horse power, then the engineer who can develop the greatest amount of *useful effect* out of that extent of heating surface, is the most successful engineer; and the man who can produce an engine at *the lowest prime cost in proportion to the work done* is the cheapest engineer. But here another element drops in. If an engineer is reckless of the quantity of coal that he uses, he can so dispose his heating surface as to make it evaporate much more than it would do if it were arranged to absorb the principal portion of the heat developed by the combustion of the coal. Therefore, the quantity of coal used in proportion to the work done should also enter into the calculation, for coal is an expensive article. The quantity of water, too, is a matter of great moment. 1 lb. of coal well managed will evaporate about 10 lbs. of water, and when an engine is working as a traction engine far from home, or as a ploughing engine on a steep and dry hill-side, it is quite possible that to supply it in such situations with water might actually be as expensive as to supply it with coal. If, then, one engine will work for a whole day with, say, 400 gallons of water, and another engine doing the same amount of work requires 1,000 gallons, surely that ought to be considered in awarding a prize.

Weight, too, is another element. A very heavy engine is difficult to move about over farm roads and along soft headlands; and if it breaks through the skin of a cross country road, it will often involve its owner in very unpleasant disputes.

The extreme width, too, of the engine ought to be limited. Few farm-gates are more than 8½ ft. in the clear. Now Messrs. Howard's engine, I believe, is 8 ft. 9 in. wide, and to pass such an implement through an ordinary farm-gate is impossible. Messrs. Aveling and Porter's engines are, I believe, 8 ft. 2 in. wide, and to guide those through an ordinary farm-gate is plainly a work of difficulty. Such wide machines, too, are very awkward on country roads, where they have to pass wagons, carts and carriages. The R. A. S. E. might easily name a maximum width, which no manufacturer intending to compete should exceed; 7 ft. seems to me ample to cover everything, and if a manufacturer cannot produce a good engine not exceeding that width, he had better give way and allow men of greater ingenuity to take his place.

It is pretty plain, too, that any engine to be useful for ploughing or traction purposes should be able to go up and down steep inclines without uncovering any portion of the heating surface that is exposed to severe heat, for it is extremely dangerous. An engine, when ploughing, may have, for many days to be working up or down an incline of 1 in 8, or even steeper. Now, if an engine be so constructed that with the ordinary supply of water its firebox would be uncovered upon such an incline, it is plainly unfit for its work.

It appears to me, then, that the Royal Agricultural Society might lay down as a *sine quâ non:*

1. That each engine intending to compete shall be capable of working as a ploughing engine, as a traction engine, and as an engine for driving ordinary farm machinery.

2. That no engine shall compete if, when working up or down an incline of 1 in 8, it uncovers any portion of its firebox to a less depth than 4 in. of water at the shallowest point.

3. That no engine shall compete if it is wider at any point than 7 ft., and to prevent this width being only temporarily diminished by decreasing the breadth of the wheels, no engine should compete if each driving wheel of the engine be less than 1½ in. broad for each ton weight of the engine, when loaded with 10 hours' coal and 2 hours' water. That is to say, a 10-ton engine must have 15-in. driving wheels at the least.

If these matters were once agreed upon, then it seems to me that the goodness of each engine in each particular department, if I may use the word, could be determined by allotting to it so many points, and whichever engine gained the most points would gain the first prize, just as in a competitive examination for the Indian Civil Service.

In making the actual trials, I think that two will be enough, for if an engine works cheaply and well as a ploughing engine, and also as a traction engine, we may safely assume it will be an economical engine for driving ordinary farm machinery. But in trying an engine with its cultivating machinery, it is a question whether it should be tried both with a plough and with a cultivator, or only with one of them. It seems to me that the plough is the implement most thoroughly understood by farmers, and is, therefore, the fairest implement by which to test the success of steam cultivation; for if it works the plough well, we may safely assume it will work the cultivator equally well.

In trying the engines as ploughing engines, each should have a plot of three acres given to it, the choice of plots being determined by lot. Then the engines and the ploughs being all in their places, the fires should be thoroughly drawn at a given signal, and the valve opened to bring down the steam to the pressure of the atmosphere. When this was done, and the judges had satisfied themselves that the fires were thoroughly drawn, and the steam pressure run down to that of the atmosphere (a watchman being placed at each engine) accurate account should be taken of the height of water in each boiler, and the quantity of water in each tender, a certain weight of coal, and a small quantity of wood and shavings should be given to each engine, and at a given signal the fires should be lighted, and the trials should commence, time being duly marked. As each engine finished its task, time could be again taken, and the results deduced as follows:

1. Divide the weight of soil moved in an hour by the square ft. of heating surface in the boiler.

2. Divide the weight of soil moved in an hour by the gallons of water used.

3. Divide the weight of soil moved in an hour by the number of men employed; two boys, provided they are really doing boys' work, to count as one man.

4. Divide the weight of soil moved in an hour by the lbs. of coal used.

5. Divide the weight of soil moved in an hour by the cost of the apparatus

Each of these things to count one point to the winner, and whichever engine gains most to have the first prize, and the next the second prize. But if any engine gains four out of the five points, that engine to get a gold medal and the first prize, and the next engine to get only a third prize. Or if any engine gains all five points, such engine to get a gold medal and sole prize, no other prize being awarded.

In trying the engines as traction engines, I should be inclined to make them start cold and draw a load over a given piece of ground, up a steep incline, say, 1 in 12. Whichever engine first brought its steam up to a given pressure should gain *one point*, and after each engine had drawn its load (of such weight as its owner might fix upon) along the given distance I would decide the trial as follows:

1. Divide the net load by the time, the winner to gain *one point*.

2. Divide the net load by the square ft. of heating surface, the winner to gain *one point*.

3. Divide the net load by the lbs. of coal used, the winner to gain *two points*.

4. Divide the net load by the gallons of water consumed, the winner to gain *two points*.

5. Divide the net load by the weight of the engine, the winner to gain *two points*.

6. Divide the net load by the cost of the apparatus, engine, and tracks, the winner to gain *two points*.

This makes eleven points in all, and if any engine should gain the whole it should receive a gold medal and sole prize, or if any engine should gain ten out of the eleven, that engine to have a gold medal and the first prize, and the next engine a third prize only. But if no engine gained so many as ten points, then the engine which gains most to have the first prize, and the next highest to have a second prize.

To prevent disputes as to what should be considered the net load, it should be arranged that the total load drawn by the engine, *exclusive of its own weight*, should be considered the net load, for if you attempt to deduct also the weight of the truck which carries the load, trucks would be used in trial far too light for practical farm work, and our object is to get not a racing engine, but one suitable for ordinary farm work.

As to pressure, it has been the custom heretofore to limit this to 50 lbs. above the atmosphere, which seems to me an unreasonable limit. When we have locomotives working at 150 lbs. and 180 lbs., why should a farm engine be limited to 50 lbs? As far as danger is concerned, 50 lbs. is quite as dangerous as 180 lbs., for every good engineer makes his boiler in proportion to the strain. At all events, a pressure of nine atmospheres, or, say, 120 lbs. on the square in. above the atmosphere, might be recognized; but each competitor might be called upon to declare the dimensions and substance of the various parts of his boiler, and the species of iron used, and if by calculation the breaking strain is found to be less than six times the maximum declared working pressure, then let the engine be disqualified.

If engineering and agricultural newspapers, too, would take up this matter and ventilate it, we might hope to see some proposal made for the trials in 1870, which would stimulate fresh engineering talent to enter the agricultural arena. A good manufacturer of railway locomotives would be a formidable competitor to all existing agricultural engineers.

THE BLAST FURNACES AT MIDDLESBOROUGH.

From the "Mining Journal."

There are now fifty-two blast-furnaces in operation in the immediate neighborhood of Middlesborough, besides ten more in course of building; there are about nine more of small dimensions, 45 ft. high, which are dormant, and are not intended to be again used. Besides these there are in the Tyne, Durham, and Whitby districts, thirty-eight furnaces in blast, two building, and sixteen not in use, giving a total of one hundred and eighteen blast-furnaces in the north-eastern district, either at work, or will shortly be available for the production of pig-iron. Of the fifty-two furnaces in the neighborhood of Middlesborough, their height varies from 60 to 85 ft., and their diameter is proportionately large. As an instance of economical management in the production of pig-iron, the blast-furnaces at Eston Junction, worked by Bolckow, Vaughan, and Co., may be cited as having adopted the latest mechanical appliances calculated to economize labor and reduce the cost of production. There are five furnaces at Eston Junction, 85 ft. high; the make of each averages about 350 tons of iron per week; one occasionally makes upwards of 400 tons per week. Hot-blast is used in every furnace in the district. There are five kilns for calcining the ore. One kiln will supply ore sufficient for one furnace. Each kiln is 21 ft. in diameter, 45 ft. high, having a circular frame-work of ½-in. iron plates, and 18-in. lining of fire-brick inside; these are of sufficient strength to carry a locomotive road on the top of them. One ton of coal is required to calcine 40 tons of ironstone. The calcined ironstone falls direct into the barrows from the bottom of the kilns, on raising the sluices placed for stopping the outlets, so that the labor of filling with shovels is saved. Behind the kilns are erected the gantry, about 45 ft. high, where the hoppers for storing coke are made. There are two hoppers, holding 600 tons each. The coke is let out as required by sluices, made at different parts on the underside of the hoppers, and runs direct into the barrows. A good deal of coke is thrown loose besides into stock, but it is no doubt more economical to stock it in hoppers only. The limestone is obtained at Forcett, and is tipped from the same gantry into stock, from whence it is taken to be broken by hand labor; this could be done to advantage by machinery. The calcined ore, coke, and limestone are now to be raised to the top of the furnaces; this is effected by water-balance machinery. There are two lifts for the five furnaces. Water is forced up to a tank at the top of each lift. There are two carriages for each lift ascending and descending, the cistern in the descending carriage being filled with water to raise the ore, coke, etc., in the ascending one. This is the usual method of lifting materials in this district, but Sir W. Armstrong's hydraulic machinery is in operation at the Clarence Works. Compressed air is used at Linthorpe and Tees Side furnaces, and a steam-engine and inclined plane are used at Acklam furnaces.

The blast-engines in the Middlesborough district are of various forms; there are several of the beam, connecting-rod, and fly-wheel type; a few of Slade's patent slide cylinders. Those lately erected are principally of uniform size and construction; they are on the inverted-cylinder principle, are supported on cast-iron framework, and occupy a small space. Steam-cylinder at top 30 in., blowing-cylinder below 66 in. diameter, 4-ft. stroke; beneath this the piston-rod and connecting-rod extend to the fly-wheel shaft, on which two fly-wheels, and an eccentric work, the shaft being being on a level with the floor. These engines go from 40 to 50 strokes per minute, and one of them is capable of supplying a large furnace with blast at a moderate speed. There are small engines, usually placed in the same house with three or four blowing-engines, for forcing water to the tanks on the engine-house and at the top of furnace lift. It should be observed that where locomotive power is not used to bring materials to the top of the calcining kilns, and coke and limestone to the gantry, this is effected sometimes by a vertical lift, where steam or compressed air is the motive power; the wagons, after being tipped or discharged, are dropped down at the opposite end of the gantry and the row of calcining kilns; as these are placed usually all in one line, with a double road on the top for the transit of the trucks from one end to the other; this is a very compact arrangement on a level surface. In a few cases these materials are raised by an inclined plane and steam-engine to the top of the gantry.

The steam-boilers used in the district are nearly all of the same type. Some of these have been 20 years in existence, at work night and day. The boilers are plain cylindrical, 70 ft. by 4½ or 5 ft., slung from five cast-iron arched girders, by three straps from each girder, attached to an angle-iron piece riveted to the boiler. The blast-furnace gas is now always used to heat these boilers, the flue being a single straight one under each boiler to the chimney-flue. In some cases the gas is sufficient to heat both the boilers and hot-blast pipes. In many of the works, however, coal is used in addition. Why this is so I am unable to explain. The blast-furnaces being closed at the mouth, the gases are brought down into large wrought-iron cylindrical tubes, lined with fire-brick. In two cases the gases are brought down to an arched culvert, made underground, and from that distributed to the various blast-stoves and boilers. The pressure of blast maintained is 3½ to 4 lbs. The temperature of blast is from 1,000° to 1,100°. A great part of the economy of these blast-furnaces is due to the high temperature of the blast, and their great height. The difference in consumption of coke is so marked as to have caused the abandonment of furnaces 50 ft. high, and erecting others in their place, 70 feet high and upwards. The large production is obtained from their great diameter. An improved boiler is used at Newport Works: it has one tube; the gas passes through this, and returns under the boiler, giving much more heating surface than that before described. The whole of the boilers in the district are covered either with bricks and mortar—an air-space intervening between that and the boiler—or they are covered in a few cases with a patent composition. Each boiler is fitted with two safety-valves, two floats, two sludgers, one float, with whistle, dial, and pointer.

The blast is heated generally in the common Λ-shaped pipes, but at Ormesby Works the blast is heated by Siemens' stoves; these are giving satisfactory results. The air after passing for two hours through one heated chamber is diminished in temperature at its exit only 100°, and is then transferred to another chamber. The Cargo Fleet blast-furnaces are run off every eight hours. A large furnace at Norton runs off the metal both in front and back at each cast every 12 hours. These are some of the principal features of the blast-furnace economy of this district; it is evident that large outlay is required for these immense structures, the engines, and mechanical appliances, but the result is to make the manufacture a more profitable one with the present process.

COMPOSITION OF SEWAGE.

THE LONDON SEWAGE—WHAT IT IS AND WHITHER IT GOES.

From "the Engineer."

By "sewage" is commonly understood anything that flows through a sewer. But the contents of a sewer are generally very composite in their character. Sewage absolute is comparatively extremely small. Apart from water supply, rainfall, and subsoil water, an average individual contributes to the sewers at the rate of only a little more than a quart per day, solid and fluid together. Dr. Parkes, in his standard work on "Practical Hygiene," gives the daily fœcal matter at two ounces and a half, and the urinary matter at forty ounces. In bulk this would be about 73 cubic inches. In round numbers this would amount in the course of a year to one hundred gallons, or a thousand pounds, or very nearly sixteen cubic feet. Reckoning the population of London at 3,000,000, the yearly amount of absolute sewage would be 48,000,000 cubic feet, equal to 300,000,000 gallons, or 1,339,300 tons. To this we will add in the first place, the rainfall, as distributed over the area of the metropolitan district. In his evidence before the Select Committee on the Sewage of the Metropolis in 1864, Mr. Bazalgette gave the area of the district as 116 square miles, with an average annual rainfall of twenty-four inches. But of this quantity the same authority reckoned that a proportion ranging from one-half to two-thirds would never enter the sewers, being lost by evaporation and absorption. Accordingly the rainfall which mingles with the sewage may be estimated at ten inches per annum over the 116 square miles, or, in round numbers, 72,-000,000 tons, equal to 2,580,000,000 cubic feet, or 16,125,000,000 gallons. With a population of 3,000,000, this will give for each individual an annual average of 860 cubic feet, equal to 5,375 gallons, or twenty-four tons. In the next place we come to the water supply. In 1867 the water companies supplied London with an average of 98,600,-248 gallons per day, of which about 81,033,-800 gallons were used for domestic purposes. A daily allowance of thirty gallons per head would be just 90,000,000 gallons for a population of 3,000,000. We may fairly take this as the quantity going into the sewers, equal, therefore, to 5,268,000,000 cubic feet, or 147,000,000 tons, being at the rate per head of 1,752 cubic feet per annum, equal to 10,950 gallons, or 49 tons, leaving the brute creation—horses, cows, donkeys, dogs, etc.—out of the reckoning. We thus form an idea as to the contents of the London sewers. The effect of the rainfall is probably under estimated. Much of the absorbed rainfall may be considerered to find its way ultimately into the sewers by percolation through the brick-work. It is also probable that the area which contributes rainfall to the London sewers is larger than the space referred to in Mr. Bazalgette's evidence.

Returning now to our figures, we observe that while each individual contributes to the contents of the London sewers at the rate of nearly 1,000 lbs. per annum (less than half a ton), this is supplemented by 24 tons of rainfall and 49 tons of water supply. Reckoned daily, these quantities become $42\frac{1}{2}$ oz. of absolute sewage, 147 lbs. of rainfall, and 300 lbs. of water supply. The total yearly average per head is 73.4 tons, equal to 2,628 cubic feet, or 16,425 gallons, the daily average per head being 7.2 cubic feet, equal to 45 gallons or 450 lbs. Reckoning that an acre of water an inch deep will weigh 100 tons, the unmixed sewage of London for one year will cover a space of 10,000 acres to the depth of an inch and a-third. But the proportion of rainfall which we reckon as entering the sewers would cover an equal area to the depth of 6 ft., while the water supply would cover such an area to the depth of more than 12 ft. A man walking through the sewage would scarcely do more than wet the soles of his boots; whereas the estimated portion of the rainfall would cover his head, and the water supply would leave him 6 ft. under. If to the proportion of the rainfall we add the water supply, we find that, whereas the unmixed sewage of the year covers 10,000 acres to a depth of only an inch and a-third, the sewer rainfall and the water supply combined will cover the same space to a depth of 18 ft. Thus, in the case of London, that which is commonly called sewage has only one part in 164 composed of pure human sewage, the remainder being rainfall and water supply. So far as the yearly average exceeds seventy-three tons per head of the population, the absolute sewage may be considered as undergoing a dilution even greater than the foregoing. The discharge from the metropolitan outfall at Crossness is often considerably in excess of this quantity. In the week ending May 29th, the daily discharge at Crossness was 238,840 cubic meters, or about 238,000 tons. Taking the population of the southern area at 1,100,000, this would show more than 48 gallons per head, or at the rate of nearly 80 tons per head per annum. In that week the rainfall was 1.12 in.

So great a degree of dilution might make it appear that London sewage was a very innocent thing. But it must be remembered that absolute sewage is an extremely powerful agent. The fœcal matter of the metropolis from human sources alone is equal to more than 209 tons per day, or 76,000 tons per year; in addition to which the urinary matter amounts to 3,348 tons per day, or 1,-222,000 tons per year. With all this there goes down a large amount of rubbish and detritus from the roads, as well as refuse fluid and material from manufactories. According to the present system of metropolitan drainage, the sewers discharge themselves into the river, the Metropolitan Board of Works providing that there shall only be two outfalls—one near Barking Creek, and the other at Crossness. As yet the former is not in complete operation, owing to the unfinished state of the northern low level sewer. On the south side the works came into full operation some time ago. We have, therefore, to consider the probable effect of casting the enormous mass of the London sewage into the Thames at the points indicated. From the Barking to the Crossness outfall is nearly two miles in a direct line. The Thames Conservancy Board, as far back as June, 1867, complained that extensive sewage shoals were being formed in the bed of the river. The report of their engineer, Mr. S. W. Leach, showed that near the northern outfall a space of more than 40 acres, and near the southern outfall of about 120 acres of the bed of the Thames was covered by a deposit of sewage mud, having a depth in some places of fully 7 ft. "The character of the mud," says Mr. Leach, "shows clearly enough whence it has come." Dr. Letheby examined some samples of the deposit, and fully confirmed the opinion expressed by Mr. Leach. "The mud in each case," said Dr. Letheby, "was black and fœtid, and in a state of active putrefactive decomposition." When examined with a microscope, it was found to consist of "broken-up sewage matter, with the remains of myriads of animalculæ, and a large quantity of carbonate of lime in a partly crystalline state." The presence of this last-named ingredient in an unusually large proportion was cited by Dr. Letheby as evidence that the alkaline constituents of the sewage were "decomposing and precipitating the calcareous constituents of the water, and thus adding to the filth of the deposit." On the attention of the Metropolitan Board being called to these allegations, Mr. Bazalgette replied that the mud deposits in the Thames, over a range of about two and three-quarter miles in the vicinity of the outfalls, had in certain places undergone an increase of 983,000 cubic yards between the years 1864 and 1867; but in certain other places along this range of the river there had been a decrease in the mud deposits to the extent of about 923,000 cubic yards, leaving the net increase, therefore, only 60,000 cubic yards. Mr. Bazalgette considered this "a very small increase in the total quantity of deposit." But it is equal to 1,620,000 cubic feet, or something more than the entire quantity of fœcal matter cast out in the space of seven months. At that date the outfalls had only been in operation for three or four years, and for a considerable portion of that time very partially. What is the present state of affairs may be soon known from the report of Mr. Rawlinson, who has been instructed by the Home Secretary to inquire into the condition of the river near Barking, the inhabitants of that locality having long ago memorialized the Government on the subject. The article quoted then goes on to show that there are evidences of the salt and sewage of the Thames permeating the bed of the river and contaminating the wells of water works on its banks, as at Crossness. As this is of merely local interest we do not quote it.

STEEL RAILS.—The gradual increase in the price of iron is indicated, not merely by the current quotations, but by the multiplication of blast-furnaces. In the Cleveland district an unusually large number of new furnaces is being erected; and although the production will be thus increased, it will probably be some time before prices will again fall. The gradual tendency to an increase of wages, caused, in part by an unusually strong disposition on the part of large bodies of workmen to emigrate, must tell also in the price of rails. In the mean time, notwithstanding the approaching lapse of Mr. Bessemer's patents, the steel rail trade continues good, and numbers of companies who have decided to employ steel in place of iron, and who must have rails, of some kind, immediately, are ordering freely in steel, the Great Northern Company being now in the market for a thousand tons. The untrue assertion, so industriously repeated in certain interested quarters, that the royalty will be diminished by £2 per ton after February next, is now understood in its true character; and railway companies perceive that even were there no general rise in prices, the diminished royalty will not be more than 18s. or 19s. a ton on that now in force, and of this the companies cannot expect to secure even a half.—*Engineering.*

UTILIZATION OF BLAST-FURNACE SLAG FOR MORTAR.

Compiled and Translated from an article in "Zeitschrift des Vereins Deutscher Ingenieure."

When, in the preparation of mortar, granulated or ground blast-furnace slag is used in the place of sand, a much smaller quantity of lime is necessary to make a well binding mortar, an advantage which is of great importance for many districts. Most blast-furnace slags, containing alumina, lime and silica in certain proportions, are dissolved by acids, the silica only being precipitated in a gelatinous state. The same takes place when natural cement is treated with acids. Blast-furnace slag, like tarrace and cement, contains silica in a condition in which it is liable to enter new chemical combinations. Silica, in the shape of sand or of quartz, forms, likewise, a chemical combination with the lime in mortar; but only when they have been in contact for a long time. The principal reason why this sand-mortar gets hard, is that the lime combines with carbonic acid taken from the air. As this combination takes place but slowly from the outside, mortar gets hard at first on the surface, the interior remaining soft for some time. If blast-furnace slag of a certain composition is used, the mortar gets hard more rapidly and through its whole mass, because the lime combines with the silica, in the same way as this is the case with tarrace (a kind of puzzolana) or with cement.

Thus mortar, made from blast-furnace slag and lime, hardens:

1. By the formation of carbonate of lime, as ordinary mortar does, and besides,

2. By the formation of chemical compounds of silica and lime.

These reactions are aided and quickened by a repeated contact with water and air. As mortar made from slags hardens quicker and more thoroughly, it does not require near so much lime and produces a more solid mass when hardened. When blast-furnace slag is ground fine it acts considerably better yet in the mortar, and can then be used even as a substitute for tarrace. It is then, also, a good material for plastering.

We communicate in the following the results of experiments, made by a committee of experts, at the Friedrich Wilhelm Iron Works (Prussia), under the direction of Mr. Langen, for the purpose of discovering the qualities and relative value of different materials used in the preparation of mortar and cement:

On the 17th of October, 1861, a number of samples of mortar were prepared from different mixtures, to be tested afterwards when hardened. The materials used were,

1. Fresh calcined lime from Ruppichteroth.
2. Rhenish tarrace, just received.
3. Ordinary sharp sand, as used for masonry.
4. Granulated slag, in pea-size.
5. Fine ground slag.
6. Portland cement of Bonn.

Different mixtures of mortars were prepared from these materials, and small square blocks, 5 in. wide and 2½ in. high, were formed of them in wooden moulds. One-half of these test-blocks were exposed to the air, the other half were laid in wet ground for several months.

On the 12th of March, 1862, the samples were inspected, and were tested as to their solidity and resistance to pressure. The pressure was applied through a lever arrangement. The weight was increased very slowly, and the pieces had to withstand for some time the pressure of a certain weight, before the latter was further increased. The results were the following:

A.—RESULTS OBTAINED WITH SEVEN SAMPLES, HARDENED IN THE AIR.

Number of Sample.	Mixture.	Results of Exterior Inspection — Appearance and Hardness.	Result of crushing test. Sample was crushed by a load of
			lbs.
1.	1 lime. 2 sand.	The sample looked and had hardened like ordinary mortar..........	1,980
11.	1 lime. 1½ tarrace. 1½ sand.	Considerably harder than No. 1...	7,380
3.	1 lime. 3 gro'd slag.	Considerably harder than No. 11. Structure fine and dense.	17,820
7.	1 lime. 5 gro'd slag.	Harder than No. 3. Equally fine and dense structure...	32,400
10.	1 lime. 2 gro'd slag. 1½ granl. slag.	Harder than No. 7. Structure less fine; the big grs. of slag distinctly visible.	21,420
13.	1 lime. 1½ gro'd slag. 1½ granl. slag.	Slightly harder than No. 10. Structure similar to No. 10........	15,080
5.	Pure Portland cement without any sand or lime.	Very hard.......	41,400

B.—RESULTS OBTAINED WITH FIVE SAMPLES, HARDENED IN WET GROUND.

Number of Sample.	Mixture.	Appearance and Hardness.	The sample was crushed by a load of
			lbs.
12.	1 lime. 1 tarrace. 1½ sand.	Not very hard...	5,600
4.	1 lime. 3 gro'd slag.	Considerably harder than No. 12. Structure fine and dense...........	11,700
14.	1 lime. 1½ gro'd slag. 1½ granl. slag.	Harder than No. 4. Structure less fine............	11,580
8.	1 lime. 5 granl. slag.	Harder than No. 14. Structure fine and dense........	25,200
6.	Pure Portland cement witho't sand or lime.	Very hard.......	42,800

The above results show that granulated or ground blast-furnace slag is a very valuable material for ordinary and for cement masonry, and that in the property of forming a very solid mortar, it stands in the middle between tarrace and Portland cement, being considerably superior to the former. The tests of the samples No. 7 and 8 prove that a great saving of lime can be effected by the use of slag. Ground slag has, therefore, a much higher value than the best sand. It looks and acts like cement, and shows the same kind of greasiness when mixed with fresh slacked lime. It would be a very valuable ingredient to mix with Porltand cement, to make the latter cheaper, and thus bring it into more extensive use. S.

PAPER BELTING.—Messrs. Crane & Co. of Dalton, Mass., have succeeded in making belting from paper, and the article is now used in all their own mills and several other manufacturing establishments. The belting is said to resemble the genuine oak-tanned leather, and to serve well both in a dry or damp atmosphere.

HEATING-FURNACE BOILERS.

From "The Engineer."

It is more than probable that as much steam is raised in Great Britain alone during each year, in small boilers, as would cost £150,000, if coal were specially burned to generate it. Furnace boilers may be counted by hundreds, if not by thousands; nearly all the iron we make in this country is smelted, and hammered, and rolled principally by the aid of steam raised from the waste heat or waste gases of our puddling, heating, and blast-furnaces. It might be supposed that everything would be known as to the generate powers of boilers so extensively used; while all that concerns their construction would have been settled on the best principles long since. Yet, strange to say, this is very far indeed from being the case. We have recently had occasion to investigate the subject pretty closely, and we find that the utmost ignorance, and probably, as a consequence, the greatest possible diversity of opinion, exists on almost every point connected with furnace boilers. No one, for example, appears to know how much steam five, ten, or a hundred square feet of heating surface in a furnace boiler should generate in an hour. An engineer putting down new works must, as far any written law goes, be absolutely in the dark. He can of course servilely copy what has been done by other engineers; but it by no means follows that he will of necessity obtain the same results. Boilers put down in apparently nearly the same way in different districts, manifest different powers of evaporation. This is bad enough, but when we turn to questions connected with the safety and durability of boilers, we find them still worse. Boilers are—we believe through ignorance—so badly designed, badly made, and badly set that explosions are of every day occurrence. Shall we say too much if we assert that the boiler engineering of our great iron districts is a disgrace to our profession?

The causes leading up to this result may, we think, be easily indicated. If once fairly examined we also believe that it is quite possible, that means may be found to raise furnace boiler engineering out of the slough of despond into which it seems to have fallen. One reason, then, why the most is not made of the furnace boiler is that it is always regarded as a matter of the most secondary consideration. The first point is that the draught of the furnace must not be interfered with. The boiler must be fitted to the draught, not the draught to the boiler. This is all right enough in one sense, and we willingly admit that when a boiler is used the heat in the stack cannot and should not be as great as though the products of combustion were thrown directly into it. But on the other hand, no one expects the products of combustion to escape from the flues of a furnace boiler at 300 or 400 degrees of temperature. The heat in the first instance is infinitely greater than it is in the flue of a Cornish boiler, let us say, and therefore even after a large proportion has been absorbed much must still remain for the stack. Is it not possible that by lengthening stacks a little it would be practicable to make furnace boilers somewhat more economical than they are?

Another reason why furnace boilers are not what they should be, lies in the fact before referred to, that no one knows how much steam any given boiler can make. No one can tell whether a furnace boiler of given construction is better or worse than another furnace boiler of totally different construction; so long as the iron gets hot soon, every one is satisfied except the manufacturer, who has to pay some thousands of pounds a year for additional steam raised in hand-fired boilers, and this while flame enough to raise twice as much steam as he gets out of these last-named boilers, is pouring from the throats of his re-heating and puddling furnaces. No one knows how much steam can be got out of a furnace boiler, because no one seems to have tried to know. In most ironworks all the boilers are coupled together, and the demand for steam in different parts of the mill is so very variable that it is next to impossible to say how much is being used, or how much is being made by any particular boiler. The only way to settle the point is to select two or three of the best types of furnace boiler, attach a good water meter to one of each type, and conduct a series of observations lasting over a month to determine how much water is really evaporated per foot of heating surface.*

We are convinced that a great field for improvement lies in the designing and construction of boilers to work with heating furnaces, and of heating furnaces to work with boilers. The sooner the matter is taken up, ventilated, and discussed, the better. At this moment keen competition has reduced the profits of the ironmaster so low that he has no money to waste in rising steam. Can none of our correspondents in the mining and ironmaking districts aid us to throw some light on the subject? Every scrap of authentic information is of value as tending to form a nucleus round which other facts may gather. Few subjects deserve more attention than furnace boilers at this moment, and we shall be pleased to hear what our practical readers have to say for and against particular types of boiler. A free discussion of the subject will be certain to do good; and such a discussion we hope to see started in our correspondence columns.

* This is a recommendation of the highest importance, and we hope it will be followed up in this country. We have recently got at some approximate results as to the evaporation in a boiler 30 ft. long, and 50 in. diameter, with two 17-inch flues, when used over a furnace *heating steel* rail ingots. The evaporation was only about one quarter as much as in the same style of boiler set in a battery, Cornish fashion and fired in the ordinary manner.—Ed. V. N. M.

ARCHITECTURE CONNECTED WITH STRUCTURES OF CIVIL ENGINEERING.

From a Paper read before the Society for the Encouragement of the Fine Arts, June 10, by Thomas Page, C. E., Acting Engineer of the Thames Tunnel, and Engineer of the New Westminster and Chelsea Bridges.

Considering that so many hundreds of millions of money have been expended in these kingdoms in works of civil engineering, and that in too many cases these works have not been distinguished by that architectural knowledge which has never been neglected in past ages, and very rarely indeed on the Continent, it is not surprising that the Council of a Society for the Encouragement of the Fine Arts, having before them the great examples of bygone days, when works of utility were coupled with artistic treatment, should draw attention to this subject at the present time, with the object of promoting a union of engineering science with the most severe of fine arts—viz: architecture.

During many ages the various kinds of works now appertaining to the civil engineer were executed by architects, and, as you are aware, the first architects were the kings and priests of the early ages. The constructors of the moles of Tyre and Sidon, the harbor of Alexandria, the port of Ostia, and all such undertakings, which were especially works of *utility*, were in reality done by engineers who were nominally architects. When, in process of time, these works of ultility increased in number and variety, in consequence of the extension of commerce and manufactures, they were entrusted to a class of men named *civil* engineers, to distinguish them from the *military* engineers, whose duties were those of attack and defense, while the former were engaged in the construction of roads, bridges, harbors, lighthouses, docks, and other hydraulic works, with their engines and machinery; and, lastly, on railways, of which about 14,300 miles have been executed in the United Kingdom.

The profession of the civil engineer is one of great importance in all progressive nations, and its members should be worthy of a calling which has numbered among its members the kings and priests of early ages, the Pontifex Maximus of the Romans, and the Christian Popes, the Cæsars, the Roman generals, and those succeeding them, down to the Great Napoleon, the offspring of the French Revolution, and the present talented Emperor, who, trained some time in England in the school of adversity, now occupies the throne of the French Empire, and exercises a controlling power in the European States.

In this country, the origin of the profession of civil engineers has been well defined in the preface to the reports of the eminent engineer, John Smeaton (the engineer of the Eddystone Lighthouse). These reports were published in 1812, and and although of great interest to persons who regard the profession of the civil engineer as an object of study, need not be further alluded to than in the following sentence.

The memoir states: "Civil engineers are a self-created lot of men, whose profession owes its origin, not to power or influence, but to the best of all protection, the encouragement of a great and powerful nation; a nation become so from the industry and steadiness of its manufacturing workmen and their superior knowledge in practical chemistry, mechanics, natural philosophy, and other useful accomplishments." From this rapid but preliminary sketch, I now come to the artistic division of the subject—"Architecture connected with structures of civil engineering," and I would draw your attention to the fact that the greater the dimensions of the structure, provided the outlines are graceful, the less the effect which can be produced by architectural decoration, because the mind, impressed by the vastness and beauty of the outlines, by the leading features of the structure, regards in a less degree those architectural features which in structures of minor importance are so pleasing. As an illustration of this idea, I will refer to two buildings which you may all know—viz: the beautiful Water Gate of Inigo Jones, now at the river end of Buckingham-street, Adelphi, and the noble structure of London Bridge, the work of the great engineering family of the Rennies. Every detail in the Water Gate is well worthy of study, and produces a most pleasing effect; but in the great structure of London Bridge, although the dentiled cornice and the simple parapet are so well adjusted as to form a most successful example of architectural application well worthy to be imitated, yet the size and proportion of the arches and piers are such that the architectural details are almost lost in the vastness and majority of the whole.

Referring back to the early works of utility, I would state that among the works of the Romans of an engineering character may be especially named those great aqueducts which supplied such volumes of water into Rome and other cities of the extended empire. These structures of essential utility were rarely devoid of architectural treatment. In some, the masonry was rusticated, the arch stones being plain, in others pilasters spring from the first tier of arches, as in the aqueduct of Merida in Spain. The division of the height of the aqueduct into arches upon arches, not only secured stability in structures so narrow, but formed a pleasing architectural effect, and a series of arches of a lesser span surmounting the whole, on which was carried the channel for the water, formed as it were an ornamental attic story, examples of which were given in the Aqueduct du Gard, that of Theodoric at Spoleto, and others. The practice of introducing small arches in the highest story of the aqueducts is followed by the architects of France as may be seen in the noble structures of Roquefavour, of recent construction, and that of Montpellier, of the last century.

There are two structures of early times to which I would especially refer on account of their lofty proportions. These are, the bridge at Alcantara, constructed in the reign of Trajan, and the Aqueduct of Spoleto, attributed to Theodoric, the truly great Gothic King of Italy, who died A. D. 526. The bridge, or "Alcantara," was constructed over the Tagus, in a depth of 40 feet of water, A. D. 105; and its height above the level of the river is 245 feet, making a total height of 285 feet, which is 80 feet higher than the towers of Westminster Abbey. It is to be deeply regretted that one of the arches of this noble structure was blown up by the British army in June 1810, when Marshal Victor menaced to cross the bridge. As to the Aqueduct of Spoleto, there are various accounts of its height. Some statements, among which is that of Gauthey, assign to it an elevation of 130 meters, while others state that it does not exceed 82 meters. The immense aqueduct which supplied Carthage, and of which Dr. Davis, the explorer of Carthage, and author of the work "Carthage and Her Ruins," has given a photograph in the frontispiece of his work, is 60 miles in length.

The character of the architectural treatment of an engineering work must of course depend upon the outline and style of the design. In a suspension bridge, the architecture of the piers is difficult, because so few forms will harmonize with the curve of the chains. In the design of the Chelsea Bridge, the piers consist of iron frames protected by an ornamental casing; each is surmounted by a large globe as a lantern. If any professional architect will examine the mouldings of the Chelsea Bridge, he will be pleased, I think, with their form and certainly will admire their execution.

But it is not, in suspension bridges, however noble and beautiful, as in the Menai Bridge, constructed by the great engineer Telford, so well known for his practical knowlege and his taste, that we must seek for the artistic feelings which this society desires to encourage. It is in the application of the arch, which in general can be applied under all circumstances, and which so well admits of architectural treatment. I have spoken of London Bridge, Waterloo Bridge, and Southwark, and I would now refer you to two designs of my own—one for Blackfriars, which was selected by the Committee of the Bridge House Lands for adoption, and the other is the approved design for Westminster Bridge. As the two designs are widely different, the treatment of them will explain my ideas of "Architecture connected with structures of civil engineering."

The great spans of the segmental arches of Blackfriars, the center arch of which is 280 feet, require piers of proportionate thickness; these are terminated above the cutwaters by massive pedestals of polished granite, intended to have been obtained from the quarries in the Ross of Mull, on part of the estate of the Duke of Argyll. These pedestals are surmounted by groups of sculpture selected from events in British history, which, in their elevated position, would have been seen with a sky outline, a condition so important for the best effect.

The imposing sweep of the arches renders ornament almost uncalled for, and so the spandrels only have an ornamented character, in which is introduced the River God and the armorial bearings of the City of London; the cornice is simple, and the parapet plain. In Westminster Bridge, on the contrary, the arches are of moderate span, the center being only 120 feet, although the radius of curvature is 250 feet, which would, with the same material at the crown, be sufficient for a semicircular arch 500 feet in span. The piers are narrow, the arches spring from a horizontal line, and sweep gently towards the center in an easy curve. This curve in the design was struck by my hand, and my assistants were directed to find what figure it was, when it was ascertained that it was a curve parallel to an ellipse. The arches, as you are aware, are not pointed arches, and it was therefore denied that the bridge is a Gothic bridge, but the arches on the tomb of Henry V. in the Confessor's Chapel at Westminster Abbey are elliptic arches, and there are examples of elliptic arches even in Norman architecture.

In such a design, then, as Westminster Bridge, it was consistent that the spandrels, cornice, and parapet, should be of an ornamental and heraldic character, and accordingly it bears in its spandrels and the panels of its pedestals the Royal Arms of the United Kingdom—those of the lamented Prince Consort; of the Prince of Wales, and the Ministers and Chief Commissioners of Her Majesty's Works who held office at the time. Instead of the massive pedestals of Blackfriars, Westminster shows a delicate and finely-worked pedestal, surmounted by the lamp standards.

To Westminster I may add the Lendal Bridge at York, of a still more ornamental character, and in which the angel which supports the Royal Arms in the center of the arch, was copied from the portrait of the Princess of Wales.

The beautiful Point du Carrousel at Paris, the work of the engineer M. Poloneeau, claims our admiration as a cast iron structure, and I need not say that Paris offers many examples of stone bridges treated in a masterly, artistic style, which do honor to the taste of the Emperor.

To determine the ornaments and mouldings for a work of the civil engineer, must depend upon great knowledge and refined taste; the buildings of the crypts, such as Westminster and Lambeth, for heavy works; those of Henry III, where admissible, according to the proportion of the arches, are most fitting; if in designs, where the Tudor arch is introduced, then the mouldings of that age. And I may here state that of all works where science and art are wonderfully combined, there has been no work before or after its time more wonderful than that extraordinary construction, the gem of Gothic architecture, the roof of the Chapel of Henry the Seventh. You must ever keep in view that the progress and perfection of artistic designs are the results of great and powerful minds, and that the employment of mediocre persons without knowledge and without taste, however wealthy may be the practitioners, must ever be a retardation to progress and discreditable to the country.

CONDENSATION IN STEAM ENGINES.

By M. E. Cousté, Government Director of Manuf.

Translated from "Annales du Génie Civil."

(Continued from page 624.)

In the surface condenser, the feed water being distilled and condensed, without mingling with cold water, there can be no back-pressure due to the gases; consequently, in the general equation (No. 5), we must cancel the terms relating to that part of the back-pressure. There is also no injection water, and the term affected by $\mu\ \Sigma$ is, therefore, equally canceled.

Equations of work in the surface condenser.—Taking into account these modifications, Eq. 5 becomes adapted to the surface condenser in the following form:

$$T\,c\,s = \tfrac{1}{3}\,S\,L\left[(P - f)\,\frac{1}{1+r}\cdot\tfrac{1}{2}\left(1 - \cos\frac{q\,(650-\theta)}{R_3\,\tau\,a'}\right) + 3f\right] \quad . \; . \; . \; . \; . \quad (13),$$

in which $\beta = 0$; for here, even more than in the injecting condenser, the heat absorbed by the condensed water may be neglected.

For metallic surfaces well cleaned we have Eq. (8).

$$a' = \frac{k}{e}\,\sigma\left(a - b\right).$$

Since a is the mean temperature of the interior surface of the condenser and varies between Θ and θ. (Θ = the temperature of steam as it enters at the pressure $\frac{P}{1+r}$) we may put

$$a = \frac{\Theta - \theta}{2}.$$

Since b is the mean temperature of the exterior surface of the condenser, if the water is rapidly circulated (a matter very essential to the good performance of the apparatus), we may admit b to be equal to the mean temperature of the water, both at the entrance and exit. As the interior surface is always covered with a very thin layer of stagnant water of condensation, and the exterior surface, notwithstanding the renewal of the water, is covered by an analogous deposit of stagnant water, protected by the rugosities of the metal, we must allow, according to Pèclet, that a' is independent of the thickness of the walls, and is simply

$$a' = k\,\sigma\,(a - b)$$

But for the co-efficient k we cannot now use the number 19.11 (in the case of a copper condenser), for a wall whose surfaces are obstructed throughout the operation, since this co-efficient is applicable only on the assumption of a perfect renewal at every instant of the water in contact with the exterior surface. We must adopt, then, the co-efficient 1.6, which results from the experiments of M. M. Thomas and Laurens, for the conducting power of copper under these conditions.

2. CASE I.—*Copper condenser with clean surfaces.*—We have, then, for the condenser with clean surfaces,

$$T\,c\,s = \tfrac{1}{3}\,S\,L\left[(P - f)\,\frac{1}{1+r}\cdot\tfrac{1}{2}\left(1 - \cos\frac{q\,(650-\theta)}{R_3\,\tau\,\sigma\,(a-b)}\,\frac{1}{k}\right) + 3f\right] \quad . \; . \; . \; . \quad (14),$$

in which expression $k = 1.6$. We shall employ k' with a value of 19.11, instead of k, when applicable to a wall whose surfaces are constantly washed by water.

3. There is between σ and θ a necessary relation, due to a periodical equilibrium, which we must assume to exist in the condenser, for we must consider the action of this apparatus from the instant at which the temperature θ becomes constant. From that instant the quantity of heat brought to the condenser by each stroke of the piston, diminished by the quantity retained by the condensed water, ought to pass through the surface σ in a time equal to the duration of a piston stroke. The quantity of heat brought by each stroke is $q \times 650$, and the

quantity to be transmitted is $q\ (650 - \theta)$. The quantity which the surface will transmit in a unit of time is $k\ \sigma\ (a - b)$; and in the time τ, or one piston stroke, $\tau\ k\ \sigma\ (a - b)$; but in taking into account the retardation expressed by the co-efficient R_s it becomes $R_s\ \tau\ \sigma\ (a - b)\ k$. Hence the equation $q\ (650 - \theta) = R_s\ \tau\ \sigma\ (a - b)\ k$; and

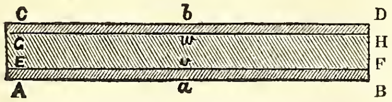
$$\sigma = q\ \frac{650 - \theta}{a - b}\ \frac{1}{R_s\ \tau}\ \frac{1}{k} \quad . \quad . \quad . \quad . \quad (14a).$$

This equation gives the minimum value σ for a given value of θ. It also clearly expresses this condition of the value of σ, that the act of condensation is simultaneous, both in its duration and termination, with the stroke of the piston. If, also, for any value of θ the surface is less than this minimum, the equilibrium will ensue at a normal temperature higher than θ. On the other hand, if the effective surface be $N\ \sigma$ (supposing $N > 1$) the work of the condenser will be less than in Eq. (14), which expresses a maximum, the effective work now being

$$T\ c\ s = \tfrac{1}{3} S\ L \left(\frac{P - f}{1 + r} \cdot \frac{1}{N} + 3 f \right). \quad (14b)$$

N being the ratio of the actual surface to the minimum surface.

4. SECOND CASE.—*Condenser incrusted on its interior surface.*—We will take the case of a plate of metal of the thickness e, covered with an incrustation of low conducting power of the thickness η, and having for a co-efficient of interior conductibility γ.



The face A B of the crust is in contact with the steam and transmits the heat to the metallic plate. This face, then, has the mean temperature a; the metallic face C D has a mean temperature b; the face E F common to the metal and the crust will then have an unknown mean temperature u. The quantity of heat transmitted per unit of time and per unit of surface of the crust is $\frac{a_{\prime}}{\sigma_{\prime}} = \frac{\gamma}{\eta}\ (a - u)$. At the moment of thermal equilibrium this quantity is equal to that which passes through the metal, having for its expression $\frac{a_{\prime}}{\sigma_{\prime}} = \frac{k'}{e}(u - b)$. Hence

$$\frac{k'}{e}\ (u - b) = \frac{\gamma}{\eta}\ (a - u)$$

Eliminating u

$$a_{\prime} = \frac{k'\ \gamma}{k'\ \eta + \gamma\ e}\ \sigma_{\prime}\ (a - b) \text{ or } a_{\prime} = \frac{1}{\frac{\eta}{\gamma} + \frac{e}{k'}}\ \sigma_{\prime}\ (a - b)$$

Substituting in Eq. (13) this value $a_{\prime}$

$$T\ c\ s_{\prime} = \tfrac{1}{3} S\ L \left[(P - f)\ \frac{1}{1 + r} \cdot \tfrac{1}{2} \left\{ 1 - \cos \frac{q\ (650 - \theta)}{R_s\ \tau\ \sigma_{\prime}\ (a - b)} \left(\frac{\eta}{\gamma} + \frac{e}{k'} \right) \right\} + 3 f \right]. \quad (15)$$

With the expression for the minimum of surface

$$\sigma_{\prime} = q \left(\frac{650 - \theta}{a - b} \right) \frac{1}{R_s\ \tau} \left(\frac{\eta}{\gamma} + \frac{e}{k'} \right)$$

or

$$\sigma_{\prime} = q \left(\frac{650 - \theta}{a - b} \right) \frac{1}{R_s\ \tau} \cdot \frac{1}{\gamma} \eta + q \left(\frac{650 - \theta}{a - b} \right) \frac{1}{R_s\ \tau} \cdot \frac{e}{k'} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15a)$$

and

$$T\ c\ s_{\prime} = \tfrac{1}{3} S\ L \left(\frac{P - f}{1 + r} \cdot \frac{1}{N_{\prime}} + 3 f \right). \quad (15b)$$

5. THIRD CASE.—*Condenser incrusted on the outside.*—If the exterior face is alone covered with a crust of the thickness ε, and of the conductibility κ, we shall have expressions anologous to Eqs. (15) and (15a), in which we may replace η by ε, and γ by κ, make $e = 1$, whatever the thickness of the metal, and replace k' by k. Thus,

$$a_{\prime}' = \frac{1}{\frac{\varepsilon}{\kappa} + \frac{1}{k}} \cdot \sigma_{\prime}'\ (a - b).$$

$$T\ c\ s_{\prime}' = \tfrac{1}{3} S\ L \left\{ (P - f) \frac{1}{1 + r} \cdot \tfrac{1}{2} \left[1 - \cos. \frac{q\ (650 - \theta)}{R_s\ \tau\ \sigma_{\prime}'\ (a - b)} \times \left(\frac{\varepsilon}{\kappa} + \frac{1}{k} \right) \right] + 3 f \right\} \quad (16)$$

$$\sigma_{\prime}' = q \left(\frac{650 - \theta}{a - b} \right) \cdot \frac{1}{R_s\ \tau} \left(\frac{\varepsilon}{\kappa} + \frac{1}{k} \right) \text{ or}$$

$$\sigma_{\prime}' = q \left(\frac{650 - \theta}{a - b} \right) \frac{1}{R_s\ \tau} \cdot \frac{1}{\kappa}\ \varepsilon + q \left(\frac{650 - \theta}{a - b} \right) \frac{1}{R_s\ \tau} \cdot \frac{1}{k} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16a)$$

and

$$T\ c\ s_{\prime}' = \tfrac{1}{3} S\ L \left(\frac{P - f}{1 + r} \cdot \frac{1}{N_{\prime}'} + 3 f \right) \quad (16b)$$

6. FOURTH CASE.—*Condenser incrusted on both faces.*—Suppose a metallic plate of the thickness e, covered with a crust of the thickness η, and of the conductibility γ on its interior face (as in § 4), and with another crust of the thickness ε and conductibility κ on its exterior face (as in § 5). Let u and w be the unknown temperatures of the faces of contact E F and G H of the metal and

crusts. During the equilibrium of temperature the quantity of heat passing in a unit of time through both of the crusts and through the metal will be the same. This quantity, considered as passing through the crust A B E F, is, according to § 4,

$$\frac{a_{\prime\prime}}{\sigma_{\prime\prime}} = \frac{k' \gamma}{k' \eta + \gamma e} \cdot (a - b).$$

Considered as passing through the crust C D G H it will be

$$\frac{a_{\prime}}{\sigma_{\prime\prime}} = \frac{\kappa}{\varepsilon}(w - b); \text{ hence,}$$

$$\frac{\kappa}{\varepsilon}(w - b) = \frac{k' \gamma}{k' \eta + \gamma e}(a - b);$$

and eliminating w,

$$a_{\prime\prime} = \frac{1}{\frac{\varepsilon}{\kappa} + \frac{\eta}{\gamma} + \frac{e}{k'}} \cdot \sigma_{\prime\prime}(a - b)$$

and the equation of work becomes

$$\text{(17)}$$

$$\mathrm{T}\, c s_{\prime\prime} = \tfrac{1}{3}\,\mathrm{S\,L}\left\{(\mathrm{P} - f)\frac{1}{1 + r} \cdot \tfrac{1}{2}\left[1 - \cos. \frac{q(650 - \theta)}{\mathrm{R}_s \tau \sigma_{\prime\prime}(a - b)}\left(\frac{\varepsilon}{\kappa} + \frac{\eta}{\gamma} + \frac{e}{k'}\right)\right] + 3f\right\}$$

for the minimum of surface

$$\sigma_{\prime\prime} = q\frac{650 - \theta}{a - b} \cdot \frac{1}{\mathrm{R}_s \tau \kappa}\varepsilon + q\frac{650 - \theta}{a - b} \cdot \frac{1}{\mathrm{R}_s \tau \gamma}\eta + q\frac{650 - \theta}{a - b} \cdot \frac{1}{\mathrm{R}_s \tau k'}e \quad . \quad (17a)$$

and

$$\mathrm{T}\, c s_{\prime\prime} = \tfrac{1}{3}\,\mathrm{S\,L}\left(\frac{(\mathrm{P} - f)}{1 + r} \cdot \frac{1}{\mathrm{N}''} + 3f\right) \quad (17b)$$

7. By equations (15a), (16a), (17a), it appears that if θ be considered as a constant, and η and ε as variables, the function σ increases very rapidly in proportion to any increase of these quantities, for the equations represent a line or plane making a small angle with the axis of σ, while, as factors, the co-efficients $q\frac{(650 - \theta)}{(a - b)} \cdot \frac{1}{\mathrm{R}_s \tau \kappa}$ and $q\frac{(650 - \theta)}{(a - b)} \cdot \frac{1}{\mathrm{R}_s \tau \gamma}$ are always very large. This shows that, if we are considering a given temperature θ, the surface condenser must have a minimum cooling surface $= q\frac{650 - \theta}{a - b} \cdot \frac{1}{\mathrm{R}_s \tau \kappa}$ relative to the incrusted metal. But if we wish to omit a specific determination of the influence of incrustations we must give to the surface a much greater extent than this minimum value, and one increasing rapidly with the thickness of the scale. Hence, as I have shown in § 2, these equations express a condition of the minimum of surface, regard being had to the development of crusts; and if this minimum ceases to be obtained by reason of that development, the temperature θ will increase until the equation of the minimum is satisfied.

8. *Maximum conductibility of the metal.*—Before discussing the equations relating to the surface condenser, it may be well to examine an experimental fact, which is very singular, and appears to be somewhat parodoxical, but upon the certainty of which engineers seem to agree. According to Péclet (who has given a plausible explanation of it by observing that a slight incrustation increases the surface, by reason of the rugosities which it produces), perfectly clean metal transmits less heat than when it is slightly incrusted. We have stated that the co-efficient of the conductibility of the metal may have two widely different values, according to whether, or not, it is placed in immediate contact with the heating body on one side, and the cooling body on the other. It follows from the experiments of Péclet, that when this immediate contact takes place (as when the surfaces of the metal are continually washed, so that the film of adherent water is perpetually renewed at every instant), the quantity of heat passing through the metal in a given time is in an inverse ratio to the thickness of the metal. But if there is no such renewal of the adherent film, the quantity of heat transmitted has no definable relation to the thickness of the plate. This is a consequence of the high conductibility of metallic bodies (the fact is quite otherwise with bad conductors); that is, in the first case, the quantity is expressed for a unit of surface and time by $k'\frac{a - b}{e}$ and in the second case by $k(a - b)$. In the case of copper k' is, according to Péclet, 19.11, and according to the experiments of M. M. Thomas and Laurens $k = 1.60$.

The difference between the co-efficients k and k' will furnish an explanation of the experimental fact which we have stated. The quantity of heat transmitted by a plate in a unit of time and per unit of surface is:

(1). In the case of metal well cleaned, but not washed during the act of absorption:

$$a' = k(a - b).$$

(2). In the case of incrustation of that face only which receives the heat:

$$a_{\prime} = \frac{k' \gamma}{k' + \gamma e}(a - b)$$

(3). In the case of incrustation of that face only which emits the heat:

$$a_{,}' = \frac{k\,\kappa}{k\,\varepsilon + \kappa}\,(a - b)$$

(4). In the case of incrustation of both faces:

$$a_{,,} = \frac{k'\,\gamma\,\kappa}{k'\,\gamma\,\varepsilon + k'\,\kappa\,\eta + \gamma\,\kappa\,e}\,(a - b)$$

and for copper we have the values

$$k = 1.60 \text{ and } k' = 19.11$$

Generally a' is greater than each of three other quantities, $a_{,}$, $a'_{,}$, $a_{,,}$, and hence

$$\left.\begin{aligned} &k(a-b) - \frac{k'\,\gamma}{k'\,\eta + \gamma\,e}\,(a-b) > 0 \\ &k(a-b) - \frac{k\,\kappa}{k\,\varepsilon + \kappa}\,(a-b) > 0 \\ &k(a-b) - \frac{k'\,\gamma\,\kappa}{k'\gamma\,\varepsilon + k'\kappa\,\eta + \gamma\,\kappa\,e}(a-b) > 0 \end{aligned}\right\}(19)$$

Now it is possible that for certain values of ε and η these inequalities may change signs, and this change would be a confirmation of the fact stated. But if these inequalities change signs, they must pass through the value of zero, and conversely if they pass through the value of zero, they must change signs. Hence, if we take for the various cases above the following equations

$$\text{2d case, } k = \frac{k'\,\gamma}{k'\,\eta + \gamma\,e}$$

$$\text{3d " } k = \frac{k\,\kappa}{k\,\varepsilon + \kappa}$$

$$\text{4th " } k = \frac{k'\,\gamma\,\kappa}{k'\,\gamma\,\varepsilon + k'\,\kappa\,\eta + \gamma\,\kappa\,e}$$

we ought to be able, if the fact stated really exist, to deduce for η and ε values greater than 0.

In the second equation $\varepsilon = 0$; hence, the fact in question does not appertain to the case of incrustation of the emitting face—a result agreeing well with the explanation proposed by Péclet; for, in the case considered, no incrustation exists upon the wall which receives the heat, the absorbing surface is in no wise affected, and it can therefore give no maximum of conductibility. From the first equation we deduce

$$\eta = \gamma\left(\frac{1}{k} - \frac{1}{k'}\,e\right)$$

This value is positive for $e < \frac{k'}{k}$.

For copper $\frac{k'}{k} = \frac{19.11}{1.6} = 12$, e does not exceed 2 millim. Hence, the fact in question exists only in the case of incrustation of the face which receives the heat. The value of η resulting from this equation will depend upon the values of γ and e. We will suppose $e = 1$ millim., for the tubes of surface condensers.

In condensers the scale is a coating formed by the dust brought in by the steam, with oxide of iron, oxide or carbonate of copper, oxide of lime, magnesia, sulphate of lime, &c. Its coefficient will be intermediate between the following, given by Péclet:

Powdered brick	.14
Powdered chalk	.108
Iron filings	.157
Peroxide of manganese powdered	.163
Mean	.14

We may therefore make $\gamma = .14$, giving for surface condensers

$$\eta = .14\left(\frac{1}{1.6} - \frac{1}{19.11}\right) = .08^{\text{ m. m.}}$$

From the 3d equation we derive

$$\varepsilon = \kappa\left(\frac{1}{k} - \frac{1}{k'}\,e - \frac{1}{\gamma}\,\eta\right)$$

The external crust is formed, generally, of carbonate of lime and free magnesia, and presents some analogy to the internal crust. We may, therefore, put $\kappa = \gamma = .14$, and hence

$$\varepsilon = .14\left(\frac{1}{1.6} - \frac{1}{19.11} \times 1 - \frac{1}{.14}\,\eta\right) \text{ or}$$

$$\varepsilon = .14\left(.57 - \frac{1}{.14}\,\eta\right)$$

The nearer η approaches in value to zero, the more nearly does ε approach to $.14 \times .57 = .08$, and in proportion as η increases, ε diminishes, until it becomes zero. Therefore the thickness of the crust corresponding to the maximum of conductibility in the surface condenser cannot exceed .08 m m.

It must be remarked here that when ε and η vary from the values just assigned, the second terms in Eq. 19 decrease very rapidly. By substituting for γ, κ their value .14, these terms become respectively

$$\frac{1}{\frac{\eta}{.14} + \frac{e}{k'}} \text{ or } \frac{1}{7.14\,\eta + \frac{e}{k'}}$$

$$\frac{1}{\frac{\varepsilon}{.14} + \frac{1}{k}} \text{ or } \frac{1}{7.14\,\varepsilon + \frac{1}{k}}$$

$$\frac{1}{\frac{\varepsilon}{.14} + \frac{\eta}{.14} + \frac{e}{k'}} \text{ or } \frac{1}{7.14\,\varepsilon + 7.14\,\eta + \frac{e}{k'}}$$

These quantities measure the efficiency of the condenser, for it is by these quantities that we must multiply the extent of surface, and the difference of temperatures $(a - b)$, to obtain the respective quantities of heat transmitted in a unit of time.

9. Let us now compare Eq. 14 expressing the work of a clean surface condenser with Eq. 7 relative to the injecting condenser, resuming in the latter the co-efficient R. Replacing the cosine by its value as a function of its arc, these equations become

$$\mathrm{T}cs = \tfrac{1}{3}\mathrm{S\,L}\left[(\mathrm{P}-f)\frac{1}{1+r}\,\frac{q^2(650-\theta)^2}{4\,\mathrm{R_s}^2\,\tau^2\,\sigma^2\,(a-b)^2}\,\frac{1}{k^2}+3f\right] \quad . \; . \; . \; . \; . \; . \; . \; . \quad (14a)$$

$$\mathrm{T}ci = \tfrac{1}{3}\mathrm{S\,L}\left[(\mathrm{P}-p)\frac{1}{1+r}\,\frac{q^2(650-\theta)^2}{4\,\mathrm{R_i}^2\,\tau^2\,\Sigma^2\,(\Theta-t)^2}+3\,p\right] \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (7a)$$

Suppose that the two condensers are equal in all respects, excepting those elements which characterize the two systems. We shall then have

$$\frac{\mathrm{T}\,c\,i-p\ \mathrm{S\,L}}{\mathrm{T}\,c\,s-f\ \mathrm{S\,L}}=\frac{\mathrm{P}-p}{\mathrm{P}-f}\cdot\frac{(a-b)^2}{(\Theta-t)^2}\cdot\frac{1+r}{1+r}\cdot\frac{k^2}{\mu^2}\cdot\frac{\sigma^2}{\Sigma^2}\cdot\frac{\mathrm{R_s}^2}{\mathrm{R_i}^2}.$$

Now $\frac{\mathrm{P}-p}{\mathrm{P}-f}$ is <1 since $p=f+f_{\prime}$; also $\frac{(a-b)^2}{(\Theta-t)^2}$ is evidently <1; k, the co-efficient for the case of metal cleaned, but having a very thin film of stagnant water upon its surface, is necessarily smaller than μ, the co-efficient of the exterior conductibility of the water; for k includes both the effect expressed by μ and the resistance of the metal to the passage of the heat. We have then

$$\frac{\mathrm{T}\,c\,i-p\,\mathrm{S\,L}}{\mathrm{T}\,s\,c-f\,\mathrm{S\,L}}<\frac{\sigma^2}{\Sigma^2}\cdot\frac{\mathrm{R_s}^2}{\mathrm{R_i}^2}.$$

Hence the work due to the retardation of condensation in the two kinds of condensers varies more rapidly than the inverse ratio of the squares of the surfaces σ and Σ, multiplied by the square of the ratio of the co-efficients $\mathrm{R_s}$ and $\mathrm{R_i}$, which is less than unity.

This inequality serves as a measure of the general superiority in principle of injecting over surface condensation through metallic plates, even without considering the effects of incrustation, which we have partially discussed. This superiority is very decided; 1st, because σ is limited by the cost of apparatus and by the space it requires, and because it is constant for a given apparatus, while Σ can be increased very considerably without increase of space or power, and can be varied at pleasure; 2d, because the co-efficient $\mathrm{R_s}$, which depends upon the friction of the steam in the tubes of the condenser and the resistance of the air in these tubes, is very small in comparison with $\mathrm{R_i}$. The principle of injection ought not therefore to be abandoned without some absolute necessity, and I shall show hereafter that no such necessity exists.

(To be continued.)

TUBE SETTING.

From "The Practical Mechanic's Journal."

Were we to go back to the commencement of the uses of tubes, when the necessity of their being fixed in series with either air, steam, or water-tight joints in tube-plates began to be understood, we should have a somewhat lengthy, but, nevertheless, interesting history of one most important detail in mechanical engineering practice to follow out. We should have to lay down in order the trials made with "tubulous" as well as tubular boilers prior to the St. Etienne experiments of 1828, to record the anxious overlooking and months of heavy toil undergone by Henry Booth, Robert Stephenson, and, we believe, Launcelot Young, in getting the "Rocket" boiler ready for the Rainhill competition; whilst in attending to this branch of tube-fixing alone any record would be but very incomplete, as it would leave out of consideration numerous other cases wherein an effectively fitted tube and plate-joint have been found essential, as in the instances of surface condensers, brewery refrigerators, coolers, *et hoc genus omne*.

Yet, however much the effective fixing of tubes has been found an engineering difficulty to carry out with close regard to economy, the methods adopted in the several instances which we have enumerated are each totally different; and compulsorily so, from the conditions governing every individual case.

In the case of a steam-boiler, the joint is required to remain tight and secure under various and, more usually, very high pressure of steam, at correspondingly intense degrees of temperature; to resist which it is necessary to insure almost atomic contact between the metal of the tube and tube-plate. Thus, expedients are resorted to, whereby intense permanent local pressure to maintain the imperative degree of metallic contact may be derived. In the case of a high pressure boiler (locomotive, for example, with the spring balance set to allow the safety-valve to blow off steam at from 120 to 150 lbs. pressure per square inch), it is almost impossible to secure by mechanical appliances, in every case, that degree of closeness of the joints so that all of them in any given boiler will be tight; wherefore it is no unusual thing to find that after all the care of the boiler-smith has been used by driving conical drifts, and followed up by the (until lately) nearly universal method of driving in conical cast iron expanding ferrules, some 40 per cent of the tube joints leak. But a boiler is *self-curative*, and we have often been on a locomotive engine running its trial mileage, with steam and water bubbling and hissing out from the tube joints at both fire-box and smoke-box ends to a highly injurious degree, yet we have examined the same boiler a few days, and sometimes a few hours afterwards, and found the leakage had stopped. But in the case of surface condensers, refrigerators, and so on, the effects of high temperature and rapid corrosion through the pressure of a corroding (*i. e.* oxidizing) liquid passing very rapidly over the leaky parts of the metallic joint do not obtain; therefore certain kinds of elastic packing, which remain uninjured at low temperatures have come into use, either of hemp, flax, india-rubber, or other fibrous or expansive material; and these have been, and continue to be, employed in a variety of forms.

In the present paper we desire more particularly to direct attention to the methods and tools employed for fixing tubes in steam-boilers; and in every case, except in one very important example with which we are acquainted, it is well here to state that such fixing is effected by *expanding* the tube end to fill the hole made in the tube-plate; whilst in most cases of surface condensers and refrigerators the tightness is secured by the *compression* of some elastic packing between the outer surface of the tube and the inner surface of the hole or recess in the tube-plate.

In regard to the fixing of tubes in boilers, the expansion of the tube end to fit the hole in the tube-plates was for a long time universally effected by the mere driving, by hammer, of a conical drift into the tube; and as the holes in the tube-plates were bored parallel, the tubes could not by this method be made to thoroughly fill the holes except at the extreme outer ends, or where the drift was of maximum diameter; nevertheless, in moderately pressed, and, indeed, we have known many cases of very highly pressed boilers, this method for a long time was the best known—additional tightness of the joint being secured by caulking the tube end and plate whilst the drift was inserted.

Afterwards, to increase the efficiency of the foregoing method of fixing by drifting, cast-iron truncated conical ferrules were introduced, so as to maintain a constant outward pressure of the tube end into the tube-plate hole; but these were found to be sources of trouble, producing difficulties in the way of cleaning the tubes, also constituting prominences at the smoke-box end, whereby small pieces of coke, coal, and ash, which, had the tubes been free from such obstruction, would have passed through them, were retained; therefore, in many cases wherein the cast iron ferules had been used, they were abandoned, and return was made to the fixing by drifting and caulking alone.

In a steam-boiler a well-fitted tube serves two purposes, namely, the provision of heating surface, and it also acts as a longitudinal stay; this latter feature has, however, in many designs for tube-fixing been entirely over-looked, more especially by French engineers, several of whom have proposed plans by which the tubes may be removed for both interior as well as exterior cleansing and scraping; but these devices are generally of that order which incurs the expense of very costly fittings, besides taking up so much more room in the tube-plate that the effective heating surface of the boiler is diminished, through the mere impossibility of putting in so large a number of tubes; and the tubes, when applied by such methods, constitute but very inefficient stays, and for this reason, we believe, have never been widely applied.

As to the importance of some not yet devised method by which the presently admissible number of tubes in a multitubular boiler may be maintained, and the tubes themselves rendered capable of expeditious removal and replacement, there cannot be a question; and the discovery of such a method promises a sure and certain reward to the inventor. For, at present, when a tube has to be removed, it is altogether useless for being replaced in the same boiler, because the ends are generally corroded into chemical unity with the tube-plate, and are bent and battered about into various tortuous forms, besides being split in the separation. Nor is this all the injury done, for it frequently happens that the hole in the tube-plate is thrown so much out of form by rust and cutting, that it has to be re-bored—that is, enlarged—to render it fit for receiving a new tube. The loss incurred through the destruction of the tube ends was felt to be so serious in one factory with which we are acquainted, that a few years ago the superintending engineer proposed to employ a knife-cutter, working in a lathe, for the purpose of squaring off the ends of the injured tubes; and he further proposed to use them again by putting on a short length of tube at one of the ends, jointing the two together by brazing over an interior ferrule. We are not sure whether the proposal was carried out extensively, and we even doubt if it could be economically and with general success adopted, for many practical difficulties appear to us to lie in the way. Of late years some of the defects to which we have alluded have been partially overcome by the introduction of tools for cutting the ends off the tubes before they are removed.

To return, however, now to consider the methods and tools employed for expanding the ends of the tubes outwards so as to fit the tube-plate holes.

Some years ago, when the necessity for doing this in a more rapid manner than by the "hammer and plug" method was seriously felt, several forms of expanding mandrels cropped up, some actuated by screw pressure, and others by hydraulic pressure; but all these have now yielded to those forms of tube expanders in which the expansion is produced by the stretching action of a series of rollers revolving inside the tube and pressed outwards by means of a central cone. Until quite recently the tool made by Dudgeon, of New York, was undoubtedly the most rapidly acting, and in all respects the best tool for the purpose which engineers possessed. Yet Dudgeon's expander has some defects, amongst which we may mention the impossibility of producing a parallel expansion of the whole length of the expanded part of the tube, so as to fit perfectly the hole in the plate, except when the central taper mandrel is driven fully in, so that the parallel upper end of it bears throughout their entire length upon the rollers; and whilst the tube-plate holes may sometimes be of size to enable the mandrel to be driven in so far, yet it can only in few cases be so.

Dudgeon's expander, although for a year or two now pretty largely used, must, we are disposed to think, give place to another form of expanding instrument introduced by Mr. Thomsom, engineer, of Glasgow; and although only a few months before the public, this instrument has been made and sold in very large numbers.

Like Dudgeon's instrument, Thomson's also consists of a central cone and surrounding rollers, Dudgeon's being *parallel*, whilst Thomson's are truncated cones. In Thomson's expander the taper of the roller lies opposed in direction to the taper of the mandrel, and the ratio of taper on each being equal, necessarily insures that points in the circumference of the rollers lie parallel to each other; thus producing a parallel expansion of the end of the tube so as to thoroughly fill the hole in the tube-plate. Thomson's expander being the most recent, we have thought it desirable, in order to give additional clearness to our previous remarks, to illustrate by woodcuts.

The instrument is made in several forms, two of which are shown at figs. 1, 2, 3 and 4; figs. 1 and 2 being an elevation and plan of one arrangement, figs. 3 and 4 a vertical section and plan of another arrangement. In figs. 1 and 2 the expanding rollers *a* are held by circularly dove-tailed heads *b* in dove-tailed radially situated recesses *c* formed in the body A, so that they cannot fall or be pulled out. When that part of the instrument which secures the rollers *a* is placed within the end of the tube to be expanded, the nut B is tightened on the screw C against the head of the body A. This has the effect of drawing the large end of the central conic mandrel inwards, and it therefore presses out the rollers *a* against the interior of the tube. When they are thoroughly tightened so as to press the tube against the hole in the tube-plate, the whole instrument is rotated in the tube by applying a winch-handle or wrench to the required end *f* of the central spindle. When the expansion of the tube has been effected, the instrument is removed by loosening the nut B, thus allowing the central spindle to be pushed inwards, and therefore releasing the pressure on the cones. In the other form of the instrument, shown at figs. 3 and 4, the action is the same as in the preceding, but the cones are held in place by the flexible steel or elastic ring *d*, which embraces recesses in their necks.

Instruments founded on similar construction to the expander have also been introduced by Mr. Thomson for cutting tubes, also for withdrawing both ferrules (when these are used), as well as the short pieces of tube from the tube-plate, without injuring the holes therein. The tube cutter is shown at fig. 5 in elevation, and at fig. 6 in

Fig. 1.

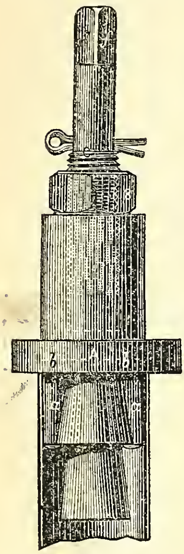


Fig. 3.

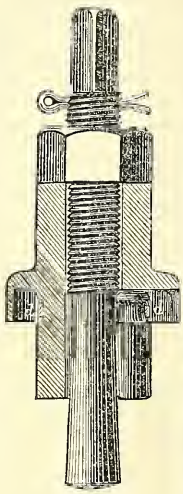


Fig. 5.

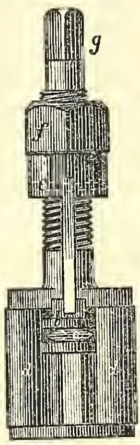


FIG.2.

FIG 4.

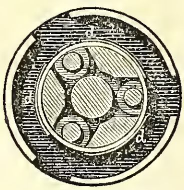
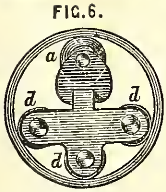


FIG.6.

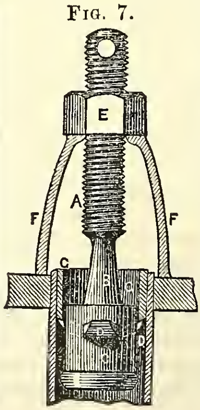


end view. The cutting disc *a* is carried on an axis in the carriage *b*, which is hinged by a bar to the body of the instrument at *c*. The body also carries rollers *d*, and in the center the taper guide *e*; and as the carriage *b* and the cutter *a* are forced downwards upon the guide *e* by the nut *f*, the cutting disc *a* is forced out against and into the metal of the tube to be cut. By turning the instrument round with a wrench applied at the squared end *g*, the disc *a* being forced out cuts an even indentation all round the interior of the tube, two or three revolutions being sufficient to cut ordinary boiler tubes completely through.

The tool for withdrawing ferrules or the cut-off ends of tubes from tube-plates is shown in elevation at fig. 7. It consists of a spindle A having a cone B formed at one end. A hollow cylinder C, fitted with a number of claws D, is fixed around the cone B, so that by tightening the nut E against the bridge F the cone B is drawn backwards; thus expanding the claws D so as to catch against the inner edge of the ferrule G, and by continuing to tighten the nuts E the ferule G is drawn out.

We have before merely hinted at one exceptional mode of securing boiler tubes, based upon the reverse foundations of what we have heretofore more especially considered; that is, the plan of M. Berendorf, of Paris, and which, we believe, has been pretty largely used by the firm of Cail & Co. of Paris. The plan consists in boring the tube-plates with holes of larger diameter than the tubes to be inserted; in the annular space which obtains around the tube when it is inserted, a double-coned ring is inserted; this, on being driven in, acts with its outward conical face, by filling the hole in the tube-plate, and the inward hollow cone becomes compressed around the tube end. Berendorf's plan is said, in certain cases, to have answered well, and we know that it is at present being looked upon attentively by boiler-making firms in the north. Our opinion of the method is that it may answer well for boilers not worked above a medium steam pressure, but it is quite evident that tubes when so fixed cannot act with nearly so much efficiency as stays, as when secured in the tube-plates by expansion outwards; and

Fig. 7.



although the system may afford more facility in the removal and replacement of the tubes, which we fully admit, still it is quite clear that the heating surface of the boiler is reduced, on account of the space taken up by the rings preventing so large a number of tubes being inserted in any given dimensions of tube-plate.

When reviewing certain methods of fixing tubes, in the foregoing part of this paper, we confined our remarks more especially to boiler-tubes. We now propose to consider what has been done to effect the same object in surface condensers.

The methods which have been at different times employed for fixing condenser-tubes may be divided into three general heads:

A. In which the packing used is metallic.

B. By means of fibrous packing.

C. By means of elastic media such as india-rubber.

Method A was proposed and first used by James Watt for fixing the tubes of his surface condensers, which he at an early date used in preference to the injection condenser. We are not informed accurately (so far as we have been able to ascertain) as to the precise details of the method by which they were fixed, but as their upper and lower ends were secured in cast iron boxes, we imagine that they must have been expanded by drifting. Similar condensers, so far as we can learn, were constructed on the Clyde by Mr. David Napier, about 1820–21, and about the same period Brunel patented another form of condenser.

Very little importance was, however, achieved with the surface condenser until 1831, when Samuel Hall turned his attention to the subject, and eventually produced such excellent results.

Fig. 8.

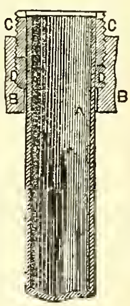


Fig. 9.

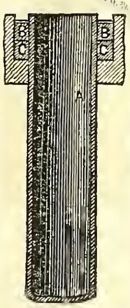


Fig. 10.

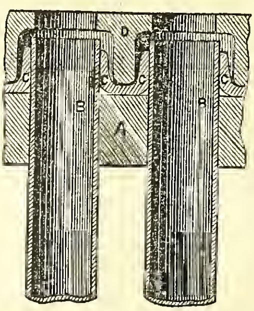
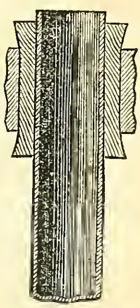


Fig. 11.



His mode of fixing is shown at fig. 8, which is a longitudinal section of a tube A fixed in the condenser tube-plate B. The hole in the tube-plate B is recessed to a considerable depth, the recess forming an annular space surrounding the tube when in its place, and it is tapped so as to receive the short screwed ferrule C, which, being screwed down, compresses the ring of hemp D into the lower part of the recess. By this means the tube is not only very effectually held in the plate, but at the same time it is allowed to expand and contract freely without straining either the plate or itself, whilst, by merely withdrawing the ferrules at either end of the tube, and picking out the hemp packing, the tube is left free for removal. We must remember that this arrangement of Hall's was the first which was found practically successful. There is no record of a surface condenser having been successfully employed in a sea-going steamer at any previous date.

As we are not at present discussing the merits and construction of condensers themselves, but one particular detail only, next in order we find Spencer's method, shown at fig. 9. This consists in recessing the tube-plate around each tube A to the depth of .125 to .187 of an inch in width, and compressing into them two or more (but usually two) india-rubber rings B C, which are put in sufficiently tight to prevent leakage when the pressure is on the outside of the plate. Then follows Sewell's; it is shown at fig. 10. This plan of fixing condenser-tubes is perhaps the most complicated of any introduced. The tube B projects some distance beyond the tube-plate A; over these projecting portions a sheet of india-rubber, formed so as to fit over the whole of the tubes, is placed. This sheet is necessarily made in one entire piece, of the same size as the tube-plates, and in it holes are formed to correspond in pitch with that of the tubes; but the holes themselves are slightly less in diameter than the tubes, so that on being placed over them the india-rubber turns up in a cup-like form round the exposed ends, as shown. Over the india-rubber sheet is an outer plate D perforated to correspond with the tubes; it is recessed, as shown, so as to pass over the tubes and surround the india-rubber cups, at the same time leaving room for the tubes to expand and contract freely when the plates are screwed together. The diameter of the holes in the outer or covering-plate is nearly the same as the interior caliber of the tubes themselves, and it serves two purposes, namely, of keeping the india-rubber sheet close against and on the ends of the tubes, at the same time preventing the tubes from working out of the plates. This method, although the most expensive, has, we believe, been pretty largely adopted of late years, but we know that some engineers do not think favorably of it.

Allen's method is shown at fig. 11; it consists merely in inserting a wooden ferrule A into an annular space in the tube-plate which surrounds the tube; this, on being driven in, becomes compressed, thereby filling the hole, and at the same time firmly holding upon the tube; but before being put in, the ferrules are first squeezed in a compressing machine.

Howden's method is shown at fig. 12. In this case the hole for receiving the tube is reduced to a depth equal to about three-fourths of the thickness of the tube-plate, and into it a short length of plaited cord is compressed, the cord being very easily and quickly inserted by means of a tool revolved in the recess by a hand-brace; this system is, perhaps, the cheapest and simplest yet devised, and is, we understand, coming into use on board of several steamers.

The last, and, so far as we can learn, a very effectual method of fixing condenser-

Fig. 12.

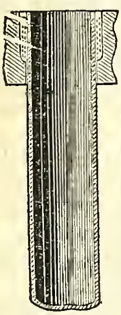
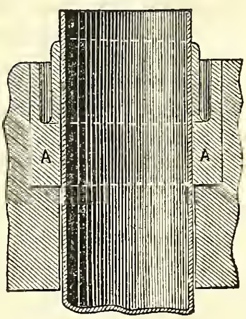


Fig 13.



tubes is that introduced within the last few months by Marshall, of Leith; it is shown at fig. 13. In this example the recess surrounding the tube is filled with an india-rubber ring A, which ring has a deep annular space formed in it, into which the water passes, having the effect of forcing the outer lip of the ring against the tube-plate, and the inner lip against the tube, thereby constituting an effective joint on both sides. Marshall's plan is being already introduced on the Clyde as well as at Leith, and the North British Rubber Company have commenced the manufacture of the rings.

We have now brought together all the more important modes of fixing surface condenser tubes, and as we shall on a future occasion probably refer at length to surface condensers themselves, we reserve further remarks on the subject at present.—V. D.

The Flow of Elastic Fluids through Orifices or Pipes.—In order to determine the number of cubic feet of steam or air, or other gas, which will be discharged through a given orifice in a given time, it is necessary to ascertain the velocity of issue. In no other way can the problem be solved, except by experiments with vessels of known capacity, from one of which the air, steam, or gas flows to the other. Such a solution is, for reasons on which it is not necessary to enter, practically beyond the reach of most men; and it has already been tried by many, with results which have enabled a general law to be laid down, to which law we shall come presently. If the velocity is known all the rest follows easily enough. Let us suppose the orifice in the side of a boiler to be one inch square. A cubic foot of steam contains 1,728 cubic inches. We may suppose this cubic foot of steam all contained in a column or bar 1,728 in. long and 1 in. square. Let one end of this bar be brought opposite the orifice and the work of expulsion begun; then it is obvious that before the whole cubic foot of steam is discharged, a column of steam 1,728 in. long must be passed through the hole. Now, if the velocity of efflux is 1,728 in. per minute, then one minute of time will be required for the escape of one foot of steam. If it have a velocity of efflux of 1,728 ft. per second, then the orifice will discharge one cubic foot per second, and so on. And this law is totally independent of the pressure or weight of the steam. As the pressure increases, the *velocity* of discharge will increase in a certain ratio to be presently explained; but the pressure will not affect the fact that the *velocity of discharge in inches per second*, multiplied by the area of the orifice in square inches, and divided by 1,728, will give the discharge in cubic fees per second.*

We have said that the velocity is regulated by the pressure, but this fact only holds good for each particular fluid. Speaking

* When a discharge of water, steam, gas, or other liquid or fluid takes place through an orifice in a thin plate, a certain contraction takes place in the issuing column which reduces the amount of discharge below that proper to the actual area of the orifice, but it is needless to do more than mention the fact here. It is quite unnecessary to complicate a statement which we wish to make as simple as possible, by further reference to the *Vena Contracta*.

comprehensively, the velocity of discharge depends on the density as well as the pressure of the fluid; the lighter the fluid the greater will be the discharge. Thus, hydrogen will issue more rapidly under a given pressure through a given orifice than will atmospheric air under the same conditions of pressure and orifice. If our readers have followed us thus far, they will be able to comprehend the nature of the law determining the velocity of discharge under given conditions of orifice and pressure. But before giving this law it may be as well to explain, that any body falling freely under the influence of gravity has a progressively accelerated rate; the velocity being in England and similar latitudes such that 16 ft. 1 in. will be traversed the first second, 48 ft. 3 in. in the next second, 80 ft. 5 in. in the the third second, and so on. The velocity of a falling body at any distance from the point where it started, may be found by multiplying the square root of the height passed through in feet by $8\frac{1}{24}$, the product being the velocity in feet per second. Thus, a bullet has been suffered to drop from the top of a tower 100 ft. high; what is its velocity at the moment of touching the ground? The square root of 100 is 10, and 10 multiplied by $8\frac{1}{24}$ gives 80.042 ft. as the velocity. Our non-mathematical readers will now be in a position to understand the law regulating the velocity of efflux of elastic fluids, such as steam, under pressure, which may be thus stated: *Elastic fluid flow into a vacuum with a velocity the same as that which a body of the same density would acquire in falling through a space equal to the height of a column of steam or gas of the given pressure.* Let us suppose that we are dealing with steam of 45 lbs. on the square inch, and the orifice of discharge has one square inch of area. Let us further suppose that a column of steam stands on a valve temporarily closing the orifice. What height must the column of steam one inch square be to weigh 45 lbs.? Avoiding fractions, nine cubic feet of such steam will weigh 1 lb.; therefore, our column of steam one inch square must contain 9 × 45, or 405 cubic feet of steam; and multiplying 405 by 1,728, we get 699,840 as the height in inches, or 58,320 as the height in feet of our column of steam.* The square root of 58,320 is 241.5 nearly, and this multiplied by $8\frac{1}{24}$, or 8.042, gives 1,942.14 ft. per minute as the velocity with which steam of 45 lbs. pressure would issue into a vacuum.

It is here necessary to explain that to avoid the introduction of a multiplicity of figures, we have omitted several fraction, and, therefore, the velocity we have given above is too low, but this in no way affects the principle of the arithmetical process we have described. Any of our readers mastering it will be able to calculate for themselves the velocity with which elastic fluids flow into a vacuum. The calculation, as we have worked it out, is, however, laborious, and for the benefit of such of our readers as understand logarithms, we give the following comprehensive rule for finding the velocity of discharge: Add 4.29 to the pressure in pounds per square inch; deduct the logarithm of this sum from the logarithm of the pressure; to one half the remainder add 3.3254, and the natural number of this sum will be the velocity in feet per second.† The difference between the velocities due to any two pressures is the velocity with which steam or air will flow into the lower pressure. Thus, if the pressure in a cylinder is 20 lbs., while that in the condenser is 5 lbs., at what rate will the steam flow from the former to the latter? The velocity proper to steam of 5 lbs. pressure is 1,552 ft. per second, while that proper to 20 lbs. is 1,919, and 1,919—1,552 gives 367 ft. per second as the velocity of the exhaust.‡

In the earlier portion of this article we stated that the actual area of the column of discharge was less than that of the orifice through which it flowed, and it is now time to say that this fact materially modifies the results of such calculations as the foregoing. Moreover, account must be taken of the frictional resistance due to the sides of pipes or tubes through which the fluid flows. On this latter subject there is considerable diversity of opinion; the subject has been keenly discussed once in our correspondence columns, and we shall not be surprised if it be discussed again. Meanwhile we cannot better conclude this article than with the following rule, extracted from "Bourne's Treatise on the Steam Engine," and regarded by many engineers as one of the best yet made on the subject. It refers to the flow of steam through a straight pipe of uniform diameter, and its relation to the

* This is an approximation only. The true volume of 1 lb. of steam at 45 lbs. total pressure is 9.000216 cubic feet.

† Sewell.

‡ These velocities have been calculated by the last rule.

rules we have laid down will be readily traced: "To the temperature of the steam in degrees Fah. add the constant 459, and multiply the square root of the sum by 60.2143; the product is the required velocity." All enlargements and contractions, and all bends or elbows, will reduce the velocity, but there is no trustworthy formula in existence which will enable us to determine exactly how much in any of the particular cases which may suggest themselves to our readers."—*The Engineer.*

BIRMINGHAM.—None, caring to trace the growth of the "work-shop of the world," need necessarily go back to the time, less than a hundred years ago, when letters were addressed "Birmingham," (or, often, Bromwicham), near Walsall," the latter being the nearest post town. The population of Birmingham, now upwards of 350,000, has doubled since 1841, and is five times what it was at the beginning of the century. Even those who have never been within a hundred miles of the place, know the general nature of its manufactures, but few are aware how these have increased in extent and variety of production. Almost exclusively a manufacturing town, Birmingham may nevertheless be said to have no cotton, woolen, flax, or silk factories, no blast furnaces or forges, no steel converting works, no work-shops for making locomotives, engineers' tools or textile machinery, no sugar refineries, paper mills, tanneries, breweries (except upon a small scale), in fact, none of those great distinctive industries which make Manchester, Leeds, Sheffield, and, in a less degree, Newcastle, Glasgow, Bristol, and other great manufacturing towns, what they are.

But there are large factories in Birmingham, where hundreds of work-people are employed in making pins, steel pens, umbrella tips, tacks, indeed the smallest articles in the largest (or, at least, in bewildering) numbers. Steel pens, for example, which once cost a shilling each, are now sold, and of far better quality, for a shilling a gross, and, of these, single establishments make from 200 to 300 millions each yearly. These are the *minutiæ* of manufactures, but there is a single establishment employing a thousand work-people, which produces a thousand million of wood screws yearly. Nearly as large a number are employed, at a single factory, in making bolts and nuts, and, besides these, iron hoops for cotton bales. And in the pen factories, including Gillott's and Mason's, in Nettlefold and Chamberlain's great screw factory, at the works of the Patent Nut and Bolt Company—nearly everything is done by machinery. The immense stride made in the manufacture of Birmingham goods during the last comparatively few years has been due to the introduction of machinery, worked in large factories, under perfect organization; whereas, previously, masters let out metals, or part-worked goods, to work-people who took them home and completed them by hand. The Birmingham gun trade was revolutionized by the erection of the immense small arms factory at Small-heath, which contains the most perfect gun-making machinery of the Enfield kind.

Of Birmingham buttons, gold and "brummagem" jewelery, nondescript hardware and knick-knacks, we cannot pretend to speak with knowledge. But turning to the larger industries, there are the historical engine works at Soho, besides smaller engine works in town; the very extensive railway carriage works of the Metropolitan Railway Carriage Company at Saltley, and Messrs. Brown, Marshall and Co.'s railway carriage works in the vicinity; Messrs. Chance Brothers' great glass works, Winfield's large establishment for making iron bedsteads and brass work, Everitt's, Webster and Horsfall's, and Cornforth's wire mills, Elkington's magnificent electro-plate works, Muntz's yellow metal works, Lloyd's and the Imperial tube works, the Stephenson copper and brass tube and roller works, Tangye's and May's engine and machine works, Morewood's galvanizing works, Piggott's and Horton's gasholder works, etc., besides the old copper mint at Soho, enameling works, manufacturies of *papier maché*, swords, files, etc., all representing distinct industries, in each of which, perhaps, two or three, or in other cases forty or fifty establishments are engaged.

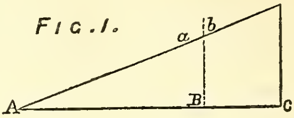
It is not, perhaps, to be lamented that Birmingham no longer produces those great works of engineering construction which she once did in the days of Fox, Henderson & Co. Their old works, the London Works, now the property of the Patent Nut and Bolt Company, turned out all the ironworks of the Crystal Palace of 1851, the great station at Birmingham, still the largest, under one roof of a single span, in the world, the Paddington Station, and the great suspension bridge over the Dneiper, at Kiev, in Russia, probably the finest individual work of its engineer, Mr. Charles Vignoles.

Birmingham is a little too far from a sea port for the cheapest transit of heavy manufactures intended for shipment abroad, but its railway and canal facilities for inland communication are unexcelled. It is a healthy town, on elevated, gravelly, or sandy soil; the latter, when in its natural state, growing a profusion of broom (Saxon *brum*, whence the name of the town), and the death-rate is much lower than in Manchester, Leeds, Sheffield, or Liverpool. There are few underground habitations—cellars—and one man in Birmingham occupies as much ground as two in Manchester, or three in Liverpool. It is only a wonder that so wide-stretching a town has not long since been tramwayed in all directions, a fact only accounted for, perhaps, by its local railway facilities. Nor is it easy to understand why some of the heavier branches of forging, steel melting, wheel making, locomotive engine building, etc., should not have yet settled there, unless it is that the business is overdone, or that Staffordshire iron, so well known for its good quality, is somewhat more cheaply worked up elsewhere.—*Engineering.*

THE MEASUREMENT OF HILLS.

From the "Building News."

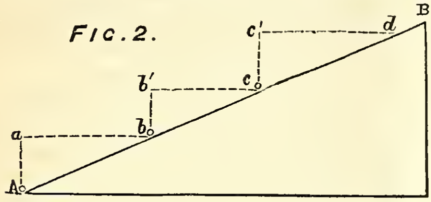
It is seldom, that a base line of any considerable length can be measured without it being necessary to make some allowance, either mechanically or by calculation, for the sloping and irregular contours of the ground. The necessity for this becomes more apparent as the surface of the ground departs from the plane of horizontality, as the greater the angle of inclination the greater will be the difference between the false and the true, or the inclined and horizontal measurement. There are various methods of arriving, at the true horizontal measurement of sloping surfaces, and the degree of accuracy to which the survey is to be carried, must in all cases determine which the surveyor will employ. It is scarcely necessary to mention that the true distance will always be less than the apparent one, and, therefore, when calculation is used, there will always be a reduction to be made. An experienced surveyor will be able to tell pretty well by the eye the allowance to be made in the majority of instances when only approximate accuracy is demanded, and the question becomes reduced to taking the next measurement or chain's



length, not from the end of the former, but from a point obtained by making the proper allowance. The diagram in fig. 1 will render this operation perfectly clear, but it is one that the young surveyor will do better not to attempt to carry into practice. We shall give a method by which the same result can be arrived at by means more suitable for a beginner. In fig. 1, suppose the chain to be stretched upon the inclined surface of a hill and extend from A to *a*, but the real horizontal measurement to extend from A to B. The point B where the chain A *a* will intersect the horizontal is found by taking A *a* in the compasses and sweeping a circle until it touches the horizontal line A C in B. If the line B *b* be projected at right angles to A C it will intersect the surface of the ground at *b*, so that the true distance to be measured along the slope by one chain's length, is not A *a*, but A *b*. From the appearance of the slope the practiced surveyor makes an approximate estimate of the distance *a b*, and the next chain's length is measured consequently not from *a* but from the point *b*, and so on, as often as may be required. The same process applies to the case of a descent as well as that of an ascent, but it is rather curious that it is invariably more difficult to arrive at a correct approximation of the rate of inclination when descending than ascending a slope. We do not attempt to offer any explanation of this somewhat curious fact, but our own experience, as well as that of numerous old and practiced hands, have confirmed the veracity of it.

The explanation of the method by which the distance *a b* in fig. 1 is estimated, will serve to indicate a mechanical mode of arriving at the same result. This latter is preferable, when carefully performed, to that given in fig. 1, and may, moreover, be accomplished by any beginner. It should not, at the same time, be repeated too often consecutively, as of course, small errors creep in at every step, which ultimately would become seriously appreciable. Let A B in fig. 2 be the sloping ground to be measured horizontally. In performing this operation we advise the surveyor to do part of the chaining himself, that is, to take the place of the "follower." If he leaves it to the chainmen to do, he may be sure that it will not be done well, as it is an operation requiring some nice and delicate manipulation. Briefly, the principle consists in taking up the chain in short lengths and holding one end vertically over the starting points, while the other

FIG. 2.



is fixed or held firmly down. In the figure let the surveyor be supposed to stand at A, with the end of the chain held vertically over the point A, by means of a plumb line and bob. In the meantime the "leader" has hold of the twenty-fifth link, suppose, which he fastens down in the proper direction at *b*; the surveyor then slacks the end of the chain, advances to the point *b*, takes up the chain carefully at the twenty-fifth link, leaving the pin in to mark the spot, and holds it over the point *b*, or, in technical phraseology, "plumbs" it over the point *b*. The "leader" has advanced to the fiftieth link, which he has fixed at *c*, and the operation proceeds in a similar manner to *d*, and until the summit of the incline is surmounted. The chain must be well stretched between the points at *b'c*, *c'd*, etc., in order to render the deflection inappreciable, so that it is preferable to take short lengths at a time, instead of long ones, although the former may demand more trouble. The steepness of the slope will also regulate the distance between the successive points of measurement, as the chain can only be raised a certain height by hand, and it is absolutely necessary that it be maintained as nearly horizontal as the circumstances of the case will allow. If this mechanical reduction of the inclined to the horizontal measurement be carefully performed, the result will be a very close approximation to the true distance. In order to get over the ground as quickly as possible, young surveyors are very apt to make the distances between the points of measurement much too long, and consequently the "sag" of the chain induces errors that might otherwise be avoided with facility. Should the hill be very short, the incline may be measured very expeditiously in the manner described by means of a good tape, provided there is very little wind blowing.

Having described the two approximate methods of reducing the sloping to the horizontal measurement, it now remains to indicate the more exact means of obtaining the same result. It is hardly necessary to observe that in large and important national and trigonometrical surveys approximate methods cannot be employed, but all the operations must be performed with the most minute accuracy. A glance at at fig. 1 will point out that there are three sides in the triangle A *b* B, one only of which is known. By the rules of proportion, as well as of equations, when one of these indeterminate quantities is to be determined, two must be given in order to solve the question. In the triangle A *b* B, the distance A *b* is given and if B *b* were known, the horizontal distance could be ascertained, since $(A\,b)^2 = (A\,B)^2 + (B\,b)^2$, or making $A\,b = x$; $A\,B = y$, and $B = z$, we have for the value of A B, $y = \sqrt{(x^2 - z^2)}$. But B *b* is the difference of level between the points A and *b*, which can be readily obtained by that branch of surveying which treats of the operations of leveling. As this will be subsequently treated of in its proper place we shall not now enter further into the question. It will be manifest that if instead of the distance B *b* being known, the angle of inclination or the angle B A *b* were ascertained, the problem could be solved equally readily. Suppose, for instance, a certain number of feet were measured along the slope in fig. 1, from A to B, the correct horizontal measurement of which was A B, but which has to be determined; let A B = N′, A *b* = N, and Θ equal the angle of elevation B A *b*. By the rules of trigonometry for solving right-angle triangles we have $N' = N \times \text{cosine } \Theta$, consequently the difference between the horizontal and the sloping measurement varies as the cosine of the angle of elevation, or, in plain terms, with the slope of the ground. The difference between these two measurements, or what is called the "reduction," is evidently equal to (N—N′). As an example, suppose N or the distance A *b* in fig. 1 to measure 100 ft., and the angle B A *b* 15°, what is the value of the correct horizontal measurement A B, and of the reduction (N—N′)? By the rule we have $A\,B = A\,b \times \text{cosine } 15° = 100 \times 0.96592 = 96.592$ ft. The reduction, therefore, is equal to (100—0.96592) = 3.408 ft. The correct distance to be entered in the field book from A to *b* is 96.592 ft., but if there is no necessity for noting the point b' on the plan, the simplest method will be to add 3.408 ft. to the 100 ft. already measured, and commence the next chain's length from that point. In other words, 100 ft. on the horizontal measurement equals 103.408 ft. on the sloping surface. From the formula and example we have given, it is readily perceived that tables can be constructed giving the reduction to be made, or the difference between the horizontal and sloping measurement for different angles of inclination. In the following table is shown the number of feet on a sloping surface inclined at various angles that corresponds horizontally to 100 ft. measured along the given slope, and also the reduction to be made for every chain's length or 100 ft. measured along the slope:

Angle of slope in degrees.	Value of 100 ft. measured horizontally.	Difference or reduction.
3	99.862	.138
6	99.452	.548
7	99.254	.746
10	98.480	1.520
12	97.814	2.186
14	97.029	2.971
16	96.126	3.874
18	95.105	4.895
20	93.969	6.031
23	92.050	7.950
27	89.100	10.900
30	86.602	13.398

If the slope continue uniform, and there are not any fences or other objects to be noted in the field book, the chaining can be continued as far as may be considered desirable, and the results in the third column given in the table multiplied by the number of chains measured. The product will give the total reduction or difference to be allowed for.

The Ellershausen Process.—We have not yet received the analyses, complete, that we promised to publish. But we are prepared to state, from the results of other and more extended experiments, that this process is highly successful and valuable. It is not so radical and revolutionary as at first supposed, but it is a decided improvement upon a preparatory process in puddling, the results being an improvement in the quality of the product, and a decided and uniform economy in its production. We shall give details in due time.

HEATING BUILDINGS BY GAS.

From "The Engineer."

The use of gas as fuel has been tried to a considerable extent in France and other countries, but the progress has neither been rapid nor very satisfactory; one reason of this lies, perhaps, in the imperfection of the modes of combustion, although something has been done of late to remedy this; another is the natural hesitation of the directors of gas works to keep pressure on their gasometers all day for a small supply.

Still enough has been done to supply a certain amount of information on the economical part of the question, both as regards gas cooking apparatus and stoves for churches and other large buildings. The average consumption of the cooking stoves in use in France which consume a mixture of gas and air is found to be as follows:—For a large fire, 260 liters per hour; for a moderate fire, 140 liters per hour; for a small fire, 50 liters per hour. When the stove is used, what the French call *pot-au-feu*, it is found that it is sufficient to keep up a large fire for about twenty minutes only, after which the gas may be turned down and the cooking completed with a very small fire. Taking the average duration of this kind of cooking at four hours, and the cost of gas at 30c. per cubic meter—the present price in Paris—the consumption amounts to 1,040.20 liters, the expense of which is 31c. 20, or little more than 14d. The cleanliness and handiness of gas as fuel, and the great economy arising from its instantaneous lighting and extinction, give it, *in the hands of careful persons*, a great advantage over charcoal, with few of its inconveniences—one of which is the impossibility of using it for broiling without a special arrangement, as the smallest quantity of fat falling upon heated charcoal fills the house with stifling fumes.

In a coal-using country, however, like England, the use of gas for the heating of apartments, and especially large buildings like churches, is of more importance than its application to cooking; and considerable improvement has been made of late in France in apparatus for the warming of ordinary rooms, to which we shall shortly have to refer more particularly.

The most important results yet produced refer to the heating of churches, which has been essayed on a large scale at Berlin. The method generally adopted is that of placing a horizontal gas-pipe with three jets within a stove made of sheet iron, and over the gas-jets a piece of brass wirework, of which the openings are not more than $\frac{1}{25}$ of an inch in diameter. The cathedral of Berlin has a cubical contents of about 17,300 meters, and it is heated by means of eight of these stoves, each of which has 22 of these brass gratings, measuring $11\frac{1}{2}$ in. in length by $1\frac{1}{2}$ in. in width, making in all about half an inch square of grating for each cubic meter to be warmed. The consumption of gas in raising the air within the edifice to the required temperature—an operation which takes three hours—is 83,400 liters, or 4.82 liters per cubic meter; to maintain the same heat afterwards requires only $\frac{7}{10}$ of a liter of gas per cubic meter.

The parish church of Berlin, whose cubic contents is 13,800 meters, is heated by four stoves, each having 15 brass gratings, each rather more than 12 in. long by $1\frac{1}{2}$ in. wide, or little more than $\frac{1}{5}$ of an inch of grating per cubic meter to be warmed. The annual consumption of gas in the cathedral above mentioned is 2,210 cubic meters, costing £20; this consumption is equal to 552 meters per stove, and 300 liters per $\frac{2}{5}$ of an inch square of grating. The consumption in Parisian churches warmed by gas is found to agree very closely with that of the cathedral of Berlin, but other cases give different results:

The church of St. Philippe at Berlin has a contents of 2,780 meters, and is heated by two stoves 1m. 40 high, 1 m. 10 long, and 65 centimeters in width, each having seven brass gratings 16 in. by 2 in., equal to $\frac{2}{5}$ of an inch square per cubic meter of the contents of the church. The annual consumption in this church is 1,485 cubic meters, or at the rate of 410 liters of gas per cubic meter of contents. But this church is only warmed three times a week.

The church of Saint Catherine at Hamburgh is heated by eight gas stoves, each having 32 brass gratings, 12 in. long by rather more than $1\frac{1}{2}$ in. wide; the cubic contents of the edifice is 33,900 meters. The heating takes three hours and a half, and consumes 220 meters of gas, costing about 27s. 6d., so that three liters of gas are required in this church per cubic meter of capacity; the temperature is kept up subsequently by the consumption of $\frac{3}{4}$ of a liter per cubic meter and per hour.

In the churches of St. Mary and Nicholas in Berlin, and in Paris also, a kind of large rose burner has been substituted for the brass grating; these are known in France as mushroom burners (*champignons*). The result with these burners in the first of the above named churches is as follows: The cubical contents of the building is 15,450 meters, and the consumption of gas in four hours is 150 cubic meters, costing about 35s., and as it is heated by ten stoves, each having three of these rose burners, the consumption per hour is $1\frac{1}{2}$ cubic meters of gas per burner, and nearly $2\frac{1}{2}$ meters for each meter of the contents of the church. In this case only we have the effect as shown by the thermometer, which is to raise the temperature of the church from one degree below zero to five degrees above, or from below thirty degrees to forty degrees Fah.

In heating churches and large buildings the economy of gas exhibits itself quite differently as compared with its application to cooking; in the former case, the more continuous the operation the less the relative cost, whereas in the latter the more frequent the interruptions the greater the economy. The objection to gas on account of its vitiation of the atmosphere of a building is one which neither the wire grating nor the mushroom burner has yet obviated.

DETERMINING THE POWER OF ENGINES.

By J. Deby, C. E.

From the "American Artisan."

Many rules are furnished in all treatises on the steam-engine for determining the horse-power, nominal or indicated, but none of them presents that scientific accuracy which alone gives real value to the results of experiments. The steam-engine (including its boiler, which is an intrinsic portion of itself) is nothing but a converter of heat into mechanical work; and consequently, in a general way, that engine which will approach the nearest to producing a maximum effect from a given quantity of fuel must be considered the best.

We know that a certain amount of any kind of fuel can only convert a certain determined quantity of water into steam of a given pressure, and we further know that this steam ought, theoretically, to do a certain amount of work. Starting from this basis, we can solve the problem without any great difficulty.

The first thing we have to do is to find out the exact composition of the fuel used. This is the duty of the analytical chemist, who tells us how much carbon, hydrogen, oxygen, ashes, etc., are contained in it. The carbon and hydrogen are alone the producers of heat, and all the other substances are absorbers of heat, and worse than valueless. Knowing the composition by weight of one pound of the fuel, if we multiply the amount of carbon contained in it by 8,000, and add to this product the amount of hydrogen multiplied by 36,000 (the units of heat evolved respectively during the combustion of one pound of carbon and of hydrogen), and then subtract therefrom the quantity of oxygen in the fuel, multiplied by 3,000, we obtain very approximately the total number of units of heat given out during the combustion of one pound of the fuel.*

If we divide this total number of units of heat given out by one pound of the fuel by the total number of units of heat contained in one pound of steam of the given tension (for which see tables or formula in the books), we obtain the number of pounds of water which might be converted into steam by one pound of such fuel in a *theoretically perfect* boiler. By carefully comparing the weight of water really evaporated in practice with the amount of fuel consumed for the purpose, we have thus an easy method furnished us for determining the efficiency of the boiler, fire-box, dampers, flues, etc.†

When we know by direct measurement how many pounds of water have practically been evaporated in our boiler by the combustion of one pound of fuel, if we multiply this quantity by the total number of units of heat contained in one pound of steam of the given tension, we find the total amount of units of heat which have been transmitted to the engine for the purpose of producing useful work. Multiplying this number by 2,000, the mechanical equivalent of a unit of heat, we obtain the number of foot-pounds of mechanical work which this amount of steam ought to produce if the engine were *theoretically perfect.*

Noting the number of foot-pounds thus developed in the space of one minute, and dividing this quantity by 33,000, we obtain the theoretical horse-power which would be derived from a *theoretically perfect* engine. By comparing the horse-power of an engine, as exhibited by the indicator, with the theoretical figure obtained by the method we have just exhibited, it becomes very easy to compute how near to, or rather how far from, perfection any particular steam-engine may prove to be. In the absence of an indicator, the "actual" horse-power may be determined by the ordinary formula for "indicated" horse-power, when the strokes per minute, length of stroke, and area of piston are known.

Let us give an example:

Supposing one pound of the fuel consumed to be formed of .92 of carbon, .63 of hydrogen, and .03 of oxygen, its calorific power would be $(.92 \times 8{,}000) + (.03 \times 36{,}000) - (.03 \times 3{,}000) = 8{,}350$ centig. units. If the engine is working steam of four atmospheres, or 59 lbs. to the square inch, each pound of steam will require for its production 651.8 units of heat, minus the temperature of the feed-water, which we will suppose in our case to be 51.8° centigrade, leaving 600 centigrade units of heat to be obtained from the fuel.

Dividing 8,350 by 600, we have 13.91 as the number of pounds of water which one pound of such a fuel could evaporate, *as a maximum*, into steam of four atmospheres. Now, if in our practical experiment one pound of fuel has only evaporated 10 lbs. of water, we see that a loss of 3.91 lbs. has taken place, equal to 39 per cent of the fuel used. *This first loss must have taken place through inefficiency in the boiler or its surroundings.* The 10 lbs. of steam of four atmospheres produced, contain $10 \times 651.8 = 6{,}518$ units of heat. Each of these units is the equivalent of 2,000 foot-pounds of mechanical work, and the 6,518 are equal to $6{,}518 \times 2{,}000 = 13{,}036{,}000$ of foot-pounds. If the 10 lbs. of water have been evaporated in 13 minutes, then $13{,}000{,}000 \div 13$, or 1,000,000 of foot-pounds will have been produced per minute, which, divided by 33,000, gives us 30 horse-power as the duty of a *theoretically perfect* engine. If, in our case, 20 horse-power only has been "indicated," then a 10 horse-power, or 33.4 per cent, would be shown to have been *lost in the engine alone* through friction, radiation, or from other causes.

In our example, 39 per cent of heat would have been lost in or around the boiler, and 33.4 per cent by the engine, showing a total loss of 72.4 per cent of the fuel burnt on the grates. Our experimental engine might

* The exact calorific values of bodies vary somewhat, according to the results of different experimenters. Those we give here are the determinations of Scheerer.

† Care must be taken, if the boiler primes, to make the necessary allowance for unconverted water suspended in the steam.

be said to be 72.4 per cent from perfection, and, in like manner, all kinds and sizes of steam-engines and their boilers may be rationally and simply classified and rated.

DRIED WOOD FOR BLAST-FURNACE FUEL.

By MARTIN MOSCHITZ, Royal Hungarian Counsellor of Mines.

Condensed and translated from "Oestr. Zeitschrift."

For a number of years it was intended to try, on a large scale, the use of dried wood in the place of charcoal in the blast-furnaces at Rhonitz, in Hungary. In 1862, all the necessary preparatory arrangements were completed, and the gradual replacement of 3, 5, 10, 15, etc., per cent of charcoal by dried wood then began. This had to be done very slowly and carefully, as the local circumstances did not allow of any interruption or disturbance of the regular working order. From this reason the increase of the percentage of wood had sometimes to be stopped entirely for long periods. However, these experiments were so successful that, from the beginning of the year 1866, the two blast-furnaces at Rhonitz have been running *exclusively* with wood, a result more favorable than was or could have been expected from the start.

In the period from 1862 to 1868, the furnace No. 1 was running during 331, the furnace No. 2 during 231 weeks, the fuel used being partly charcoal alone, partly charcoal and wood mixed, partly wood alone. The amount of materials melted were:

581,657 cwt. (Austrian) ankerites, poor spathic ores, and brown hematites.
371,832 cwt. granulated cinder from puddling and heating-furnaces.
296,917 cwt. calcarious and dolomitic fluxes.

1,250,406 cwt.

The fuel used amounted in that period to
4,981,974 c. ft. (Austrian) of soft charcoal (including 10 per cent loss).
4,709,899 massive c. ft. of pine wood.

The products obtained were
294,760 cwt. gray forge-pig.
71,700 cwt. castings.

366,460 cwt.

The percentage of iron in the mixture for forge-pig was 38.45, that in the mixture for foundry-pig 29.30. The charcoal weighed about 7 lbs. per cubic foot; some of it less. From 40 to 64 per cent of charcoal, by volume, have been obtained from the wood by charring, or 19.08 per cent by weight.

To be able to compare the amount of fuel used when the furnaces were run with wood, to the amount used when they were run with mixed fuel or with charcoal alone, it is necessary to convert, in the calculations, all the wood used into the corresponding weights of charcoal. It has thus been found that the amount of charcoal used for the production of 100 lbs. of pig-iron has been, on the average, as follows:

(*a*) In smelting with charcoal alone.. 195.09 lbs.
(*b*) In using 13.58 c. ft. of soft charcoal .... 95.06 lbs.
and 12.84 massive cubic ft. of wood, weighing 31 lbs. per c. ft., the corresponding weight of charcoal is $\frac{12.84 \times 31 \times 19.08}{100}$ ... 75.95 lbs.

171.01 lbs.

(*c*) In using wood alone (since 1866):
1. During the first 25 weeks were used 28.66 massive cubic feet of wood, the corresponding weight of charcoal is— $\frac{28.66 \times 31 \times 19.06}{100}$ ...... = 169.52 lbs.
2. All the rest of the time, up to this day, 27.02 massive cubic feet of wood the corresponding weight of charcoal....... = 159.82 lbs.

It is to be seen, from this statement, that by using wood instead of charcoal a saving of fuel is effected, amounting to (195.09 less 159.82) = 35.27 lbs. or 5.71 cubic ft. of charcoal, or 5.93 massive cubic ft. of wood, on 100 lbs. of iron produced. This is an actual saving of 18 per cent of fuel.

One pound of charcoal costs, at Rhonitz, .81 kreutzers (Austrian). [1 Austr. kreutzer is equal to about $\frac{1}{2}$ cent in gold. 1 florin = $48\frac{1}{2}$ cents gold = 100 kreutzers.]

One massive cubic foot of wood costs	3.9 kreutzers.
Transport, cutting and drying......	.8 "
Total cost of one massive cub. ft. of wood ready for use at the furnace,	4.7 "

From these data the saving in money, effected on 100 lbs. of pig, is calculated thus:

195.09 lbs of charcoal at .81 kreutzers = 1 florin...............	58.02 kreutzers.
27.02 massive cubic ft. of wood at 4.72 kreutzers = 1 florin......	27.53 "
Leaving per 100 lbs. of pig......	30.49 "

As the cost of 100 lbs. of pig amounts to about 2 florins and 30 kreutzers, the above saving corresponds to 13.2 per cent in money. This saving is, of course, the more considerable the higher the price of charcoal stands, when compared to that of wood. Fifty per cent of granulated puddling and heating cinders in the mixture are easily reduced and melted when dried wood is used as fuel.

The bast-furnaces in which the above results have been obtained are 42 ft. high, $3\frac{3}{4}$ ft. wide at the bottom, 12 to 13 ft. in the boshes, and 6 ft. at the top. They are shaped like the "blanofen" in which the Prussian spiegeleisen is made, the boshes running clear down to the bottom of the furnace in one steep incline. The mantel is carried by six cast-iron columns. The top is shut by a movable cover. Each furnace has four twyers into which the nozzles of the blast-pipes are fitted in tight. The nozzles are $2\frac{1}{6}$ in. in diameter. The blast has a pressure of $1\frac{1}{2}$ to 2 in. of mercury, and a temperature of 400° to 480° Fahr.

The gases are caught by a cylinder reaching 3 ft. into the mouth of the furnace. The circular space between the cylinder and the wall of the furnace is covered by a cast-iron plate with seven round openings equally distributed, through which the gases escape into seven vertical pipes all ending above in a horizontal circular pipe. Another pipe of sheet-iron, provided with a valve, communicates with the latter, and carries the gases to the places where they are wanted. The circular pipe has seven round openings above, situated in the prolongations of the seven vertical pipes mentioned. These openings, with short additional pipes cast on, are covered slightly by sheet-iron caps, which, like safety-valves, prevent the destructive effects of explosions. They also serve for the cleaning of the apparatus, and can be used to let the superfluous gases escape. The cylinder in the mouth of the furnace is necessary to prevent the atmospheric air, and the steam developed from the charged materials, from entering the gas-pipes. The sheet-iron main pipe carries the gases down 47 ft. to the general working level, and afterwards to a horizontal distance of 156 ft.

The cutting and the chopping of the wood is done by one and the same machine, which is of a peculiar construction. It consists of two steel blades working together like plate shears. The lower blade is fixed; the upper one moves up and down in a vertical frame. The blades are not straight, but are bent horizontally to a half circle, and their cutting edges are not even, but receding vertically in an elliptic line, so as to start the cut from both sides of the log held between the two blades. The logs, mostly about 12 in. thick, are cut in blocks from 3 to 6 in. high, which blocks are afterwards chopped in smaller pieces by the same machine. As all this is done by regular cutting, no saw-dust is produced. The cutting surfaces of the wood thus treated are not very even nor smooth, which circumstance facilitates the escape of the water in the following operation of drying. The above-described machine works day and night, cutting from 4,000 to 4,800 massive cubic feet of wood in 24 hours. The expenses for cutting by machine and drying of 100 massive cubic feet of wood, amount to about 30 kreutzers. Sawing and chopping by hand of the same quantity would alone cost about 95 kreutzers. In adding to this the expenses for drying, the sum would be too high to be paid for the preparation of wood for the blast-furnace. The wood, after being cut small, is filled directly into the charging wagons, holding about 20 cubic ft. The wagons are pushed into the drying-ovens without being unloaded, and when the wood has been dried, the wagons are conveyed to the top of the furnace. The drying-stove is a brick-building consisting of four parallel compartments. Each compartment is 48 ft. long, $4\frac{1}{2}$ ft. wide, and 5 ft. high, and has a door at each end, the one of which is the charging-door where the wagons filled with wood are pushed into the stove; the other door at the opposite end is the discharging-door, where the wagons are taken out one by one after the wood has been dried. A railroad with an incline of 3 to 100 passes through each compartment, so that the wagons, when pushed through the charging-door, roll of themselves towards the discharging-door. The stove is heated by the waste gases from the blast-furnace. It is, however, provided with a step-grate, on which a small fire is kept burning to re-light the gases when they have been extinguished during the charging of the blast-furnace.

The flame passes from the fire-hearth, near the discharging-doors, into four brick flues running below the floors of the four drying compartments, throughout their whole length; after this the gases pass through the hollow side walls of the compartments back to the vicinity of the discharging-door, where they find an outlet into the interior of the compartments, and thus come in direct contact with the wood. They finally pass, together with the steam that evaporates from the wood, through a flue near the charging-door, and escape into the stack.

It is to be seen that with this arrangement the wagons containing the wood pass gradually from the cooler into the hotter parts of the compartments. Each compartment holds 12 wagons, each wagon 20 cubic ft. of wood, the whole stove 48 wagons with a total volume of wood of 960 cubic ft.

At Rhonitz there are only 48 wagons in use, all told, and as a part of them are always on the way to and from the blast-furnaces, not more than 30 wagons are generally in the stove at one time. Both blast-furnaces require about 18 wagons of wood per hour or 60 minutes. Consequently the average time used for drying is about $\frac{30 \times 60}{18} = 100$ minutes, or one hour and 40 minutes.

Most of the wood used has been cut a year beforehand, and is therefore pretty well dried out in the air before being brought into the stove. It loses in the stove about eight per cent of water.

The practical management of a blast-furnace, when run with wood, does not differ essentially from the ordinary charcoal practice. The gas-pipes have to be cleaned oftener and more carefully, because the products of distillation from the wood settle partly in these pipes. The setting-in-blast of a furnace has, of course, always to be done with charcoal. However, after but a few days running, the fuel can be changed, and wood can be used exclusively, provided that the quantity of ore which the wood is able to carry under the existing circumstances has been ascertained by previous experiments. It is, however, very important when wood is used, to make the charges about 60 per cent larger than with charcoal, and to increase the pressure of the blast 10–20 per cent. With too small charges the considerable shrinkage of the wood is liable to produce irregularities in the descent of the ores in the furnaces. The higher pressure of the blast is necessary, because the carbonization of the wood being effected under more favorable circumstances and under a higher pressure in the blast-furnace than in heaps or piles, a considerably better and denser charcoal is produced, which requires a stronger blast to be burnt to full advantage.

The different and better quality of this charcoal has been practically ascertained at Rhonitz by a close examination of charcoal extracted from the lower parts of a blast-furnace running with wood.

It may be concluded, from what has been said above, that dried wood can be used to great advantage in blast-furnaces of at least 1,200 c. ft. interior capacity; when the ores do not pass through the furnace in less than 10 hours; when the wood is cut small, well dried and warm yet when charged; finally, when the top of the blast-furnace is closed, so as to avoid all the disagreements and disadvantages of an open and too hot furnace-mouth.

The use of wood in blast-furnaces has been tried as early as the end of the last century, and the trials have been repeated often in different places. They were, however, without success, from the following reasons. The furnaces were too small and open at the top. The preparation of the wood was done by hand, consequently very expensive, and the wood was not reduced to the proper size. The charges were taken too small, so that irregularities in the smelting ensued.

Explosions have been complained of in some places where the use of wood has been tried. But such have not been experienced at Rhonitz.

The advantages of the use of dried wood in blast-furnaces, in the place of charcoal, may be summed up as follows:

1st. Tops and small branches of trees, the carbonization of which cannot be effected in heaps or piles without a very considerable loss, may be used in the blast-furnace to great advantage.

2d. The whole process of carbonization is done in the blast-furnace in a more advantageous and less expensive manner, so that 18 per cent of charcoal is saved, and all the work that would have had to be expended on its preparation, beginning with the cutting of the trees.

3d. The furnace works well and with great regularity, and preserves a very clean hearth.

4th. Ores or other materials, which melt easily but are difficult to reduce, can be worked more advantageously with wood than with charcoal, as it is shown by the great amount of puddling-slag that has been smelted at Rhonitz, partly mixed with ores, partly alone. The greater density of the charcoal made in the blast-furnace seems to favor the reduction of these matters.

On the other hand the following disadvantages have to be taken into consideration:

1st. The expenses for cutting and drying of the wood are considerable, though with the machinery used at Rhonitz they are not as high as those for charring.

2d. The cost of transport is greater, because the heavier wood has to be conveyed to the furnaces instead of the lighter charcoal. This disadvantage is but small when the wood can be obtained pretty near the furnaces, and it increases with the greater distance from which the wood has to be fetched.

3d. As above-mentioned, it is necessary to clean the gas-pipes oftener. This disadvantage can, however, be entirely removed by erecting an apparatus for cleaning the gases from all the easily condensing substances. By this operation tar would be obtained, the value of which would pay for the expenses.

In general it may be said, and it has been proved by long practice at Rhonitz, that the disadvantages connected with the use of wood in blast-furnaces are by far out-weighed by the great savings effected by it when properly managed, and it is to be expected that the use of wood will enable many charcoal furnaces to withstand the increasing competition of the coke and anthracite furnaces. S.

RAILWAY DISASTERS.

WHAT KINDS OF DISASTERS CAN BE EASILY PREVENTED BY LEGISLATION.

From the "New York Times."

The awful frequency of railway disasters has at last set people to thinking whether some practicable means cannot be devised to prevent or lessen the horrors that attend them; and many theories of railway safety have been set forth in the newspapers by unprofessional experts, to the utter bewilderment of the public. But we have yet to learn that a single step has been taken by railway managers or by the Government to abate certain unquestioned and notorious causes of disaster which we shall enumerate —causes as well defined at Angola, Carr's Rock and Pine Tree, as at Mast Hope.

The misplacement of switches, for instance, even by men considered careful, often occurs, but the English system of signals would warn both engineman and fireman of the fact in *ample time to stop.* Hundreds of lives might have been saved by thus widening the range of notice and responsibility—it is almost impossible that three men will blunder in such a matter at the same instant—and yet not one in five hundred switches, passed by express trains at the top of their speed, is so guarded. We have, on a previous occasion, shown that not less than five men, practically asleep at Mast Hope that fearful night, might have saved the train if the appointments and regulations of the road had been adequate.

The preservation of trains from wreck, by safety brakes instantly applied to all the wheels, must have been a matter of experience with many of our readers; it has been so not less than three times with the writer, on one of the roads leading out of this city. But the use of such brakes is hardly increasing, and is not general.

An American train being connected merely by slack couplings, each car is free to sway laterally and vertically, even to the extent of jumping off the line, without restraint from the adjoining cars. The late Pine Tree disaster was, in the opinion of experts, especially of English engineers, who have commented severely upon it, greatly aggravated by this cause, and it is certain that many slight mishaps have grown into awful catastrophes for the want of the simple English appliances by which a train becomes an articulated whole, instead of a series of disjointed and independent pieces, each surging about without any restraint. On one of the few American lines where this system has been partially applied, it has been substantially neutralized by *adding the old links*, which are, of course, always used to save trouble.

Experts generally are of the opinion that a narrow-gauge car cannot run with the highest safety through wide-gauge frogs and guard-rails—in fact, that the late fearful Angola slaughter is a case in point—yet the inch and a half difference of gauge remains, and the number of cars suited to the one, and consequently unsuited to the other, but run over both, is constantly increasing.

The breaking of rails does not often occur when reasonable care is taken as to their quality and laying. Yet it is the opinion of the many engineers whom we have consulted, that a reasonable measure of safety cannot be secured without continuous longitudinal sleepers, or some mechanical equivalent thereof, which shall hold the broken pieces of rail in place long enough to pass a train in safety. But there is nothing of the kind in use.

Again, if there is anything clearly and positively settled in railway practice, it is that ricketty "permanent way"—broken chairs, rotten sleepers, loose spikes and rails, with parts of the head split off—are utterly and frightfully unsafe. But we will undertake to show any competent Government committee just this kind of track *by the hundred miles*—track that any commission of experts would refuse, upon examination, to ride over at high speed, and which is habitually left in this condition month after month. Yet when trains run off tracks of this general character, juries are utterly at a loss to account for it, and fall to speculating on the occult molecular differences in irons, the moral character of employees, and everything but what is obvious and pertinent.

There are in New England hundreds of old wooden bridges, designed when the stress put upon materials was much nearer the limit of strength than is now deemed safe—bridges that have deteriorated in the alternate rain and shine of twenty years, and which, being built for fifteen or twenty ton engines, are to-day straining under those that weigh 25 and 30 tons—bridges in which, according to engineers and bridge-builders, whom we have consulted, the iron rods are strained, when two engines happen to meet, up to 50,000 lbs. per in., when 10,000 lbs. is considered a safe working load. Now and then a wooden bridge falls under a train, and it is a dreadful but inevitable conclusion that hundreds of lives are yet to be sacrificed in this manner.

The most unnecessary, and at the same time the most frightful risk of railway traveling is yet to be mentioned—it is the risk of mangling and roasting by the splinters of the wooden car, that comprehensive and labor-saving engine of torture, for which, had the Adversary hatched it in their day, the Spanish Inquisitors would have thrown aside all their limited and clumsy contrivances. Upon violently striking any rigid object, the wooden passenger car is as certain to go off as a bombshell, with this advantage over the bombshell, that it has a percussion fuse at every angle, and completely surrounds the objects it is to destroy. Seriously, the wooden car is *certain to break up* in case of collision or derailment at high speed, and then the burning of the passengers is probable—their mangling is inevitable. Every few months, men, women, and little tender children are tortured to death, and this awful fate is certainly reserved for some of us. But not a single step has been taken by railway managers to abate this evil, though the remedy is practicable, and even economical in the long run. Iron cars neither splinter nor burn, and will out-wear wood again and again—yet we do not know that a single iron passenger car is contemplated.

We have thus specified a few of the most notorious and unquestioned causes of railway disaster—causes which do not involve the so-called hidden and unsearchable nature and changes of materials, nor any mere theories of construction, nor the vigilance and responsibility of employees. The remedies for all these universal, unfailing and ever-menacing evils are precedented and practical; some of them are almost ridiculously inexpensive; some of them would save their cost every year in lessened wear and tear, and all of them are feasible, simple and unembarrassed subjects for legislation. How many more murders will our law-makers ignore?

STEAM BOILER INSURANCE IN AMERICA—THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.—However unfortunate we in England may be in the matter of steam boiler explosions, no one can fail to have observed that our friends in the United States are still more so. The annual loss of life and property there, from this cause, must appear very large, even to the casual observer, whilst to those whose attention is frequently drawn to the subject, the results are really startling. It will be sufficient for the present purpose to allude to the record for the past two years, as it found its way into the papers. Such a record is, of course, a very incomplete summary of the number of lives lost, and the amount of property destroyed by boiler explosions in the time specified. Many explosions of a more or less serious nature are never reported by any newspaper, or, if reported, fail to meet the eyes of those interested in preserving an account of them. Incomplete, however, as it is, when we note the fact that, during two years, upwards of 800 lives have been lost in America by boiler explosions, and an immense amount of valuable property destroyed, ranging—in the various instances where any estimate was given—from $500 to $50,000, it demonstrates very conclusively the need of such a system of boiler insurance and inspection in that country as we have in our own. This necessity has been recognized—somewhat tardily, perhaps—by the Americans, who took a leaf out of our book, and in 1866 started "The Hartford (Conn.) Steam Boiler Inspection and Insurance Co.," about which association we have to say a few words. We are induced to do this from the fact that our journal finds favor in many parts of the States, where our persistent advocacy of boiler inspection is well known, and where the advantages of the system are admitted. If, then, the correctness of the principle be allowed, and if we point out to those who may not be aware of it, that American steam users have the same opportunities of making themselves safe as we in England have, there remains no excuse if they do not avail themselves of the means offered.

The Hartford Association is the pioneer company of the United States, and from particulars recently forwarded by a correspondent, we find that during the two years and a half it has been in operation, it has extended its business by a system of well appointed agencies over a great part of the country. Many of the largest manufacturers hold its policies, and its rapidly increasing business attests the value of its work. Its business is confined to no particular form of boiler, nor to any special class of manufacturers. It embraces ironworks, mines, cotton and woolen mills, saw mills, locomotives, steam-boats and steam-tugs, and, in short, all establishments where steam-power is used. All boilers under its care are carefully inspected, internally and externally, by competent practical men four times a year. Steam gauges are tested, safety valves properly adjusted and weighted, boiler connections carefully examined, and information given relative to setting and management. The end and aim of all this, be it remembered, is economy in the use of fuel, and safety to life and property. As a matter of course, the work of the company has brought to light many and dangerous defects; and there can be little or no doubt that disastrous explosions have been prevented. We know that where boilers are left unexamined for months and years together, incrustation, internal and external corrosion, burned plates and blisters, shorten their working age, and render them positively dangerous. The usual mode of inspection, applying the hydraulic test, takes no cognizance of these defects, and does but little towards insuring safety. The policy of insurance which the company issues, covers damage to boilers, buildings, stock and machinery, arising from explosions, and is a guarantee that the inspection has been thoroughly effected. It stands to reason that self-interest would cause the work to be properly done, inasmuch as the party making it has a pecuniary interest in its issue.

The company imposes no arbitrary conditions; it is interested in no patented appliances, but on receipt of the proposal for insurance, together with the inspector's report, the boilers are classified and accepted at a proper rate per cent, unless they are found on inspection absolutely unsafe, in which case the applicant is furnished with a written statement of their condition. Information relative to the management of steam boilers, monthly reports of the inspectors of the company, a list of explosions, so far as they can be obtained, for each month, and other valuable information, is disseminated amongst the policy-holders by means of a monthly paper called "The Locomotive." From what we have advanced, it will be seen that the Hartford Association is conducted upon equitable principles. The present remarks are penned with the view of promoting the interests of those steam users who are indifferent to themselves, and of increasing public safety. We, therefore, trust that they may lead those who may read them, and who have hitherto held back, either from ignorance or obstinacy, to avail themselves of the manifest advantages of inspection and insurance. It is an old and oft-reiterated opinion of ours, that it is due to the State that every man should adopt every precaution in his power to protect the life and property of his fellow subjects. A persistent disregard of this principle is a flagrant violation of the moral law, which the State will not always permit with impunity to the offender. —*Mechanics' Magazine.*

The Corliss Engines at Woolwich Arsenal, are using from 3.3 lbs. to 3.7 lbs. of coal, per hour per horse power, as shown by the daily engine reports.

BETON BUILDING.

From "The Canadian Builder."

Of all the compositions which in late days have been introduced as substitutes for brick and stone-work, there is not one that presents more attractions as a material than beton. But the use of it is limited to those localities where water lime can be had at a reasonable price. For, although that admirable cement is about the only one of its component parts that is expensive, yet the proportion used makes the beton more costly than could be wished, notwithstanding its many merits as a building material. There need not be any stone or stone chips used in the making of beton. All that is required to make a quick setting and very durable material is, sand, three part; water lime, one part; broken brick, six parts. The water-lime and sand should be well mixed together, dry. Then have as much water thrown over as will make a moderately stiff mass, when it is to be instantly transferred to the moulds, which are already in their place on the walls, and the center to be packed with the broken brick, which being very porous, will receive the moist cement readily on its broken faces, and help to set the whole. The mode of constructing the courses is by means of moulds easily adjusted and taken apart. They are to be calculated so as to enclose a block of beton of the required thickness of the wall, and half again that thickness in length. There height may be ten inches. Thus, if the wall be twelve inches thick, the block will be the same, and also eighteen in. long by ten in. high.

We will proceed to describe the operation of building as carried out in the construction of a beton house at Black Rock, near Buffalo, some years ago. The lines being laid out, the basement was excavated to the depth of six feet, and the trenches for the foundation walls dug out one foot and a half below the bottom of the basement. These trenches were two ft. and a half wide, that is, three in. each side wider than the basement wall above them. The basement was therefore dug three in. wider than the plan all around, and this was done to leave room for the placing of the moulding boxes with their rods. The bottom of the trenches was made level, and these were filled with concrete composed of six parts gravel, four parts sand, one and a half parts quicklime, with sufficient water. When this mass was well mixed and turned over three or four times, it was thrown into the trenches in layers or courses of four in. in depth. Each course was spread over the whole of the foundation trenches, until they were all, including the foundation of cross-walls, filled. When the surface of the basement or cellar bottom was reached, then the whole area was gone over with a coat of gravel, and over this was poured a creamy mixture of water lime and sharp river sand, in equal proportion, until the whole was flush. This was done on Saturday, and on the following Monday the floor was hard enough to walk upon. The basement walls were now commenced in the manner here described. The lines of the walls as shown on the plan were carefully laid out, and angle-moulds placed at each corner, with straight moulds set at equal distances all along.

One corner mould and three or four straight moulds are sufficient to work with; but the greater the number of moulds the more expeditiously the operation of building goes on. When all was ready, the corner moulds were filled first, and then the other moulds regularly in turn. When all were filled, the moulds were taken apart and set up at other points along the walls; but sufficient time was given for the beton to become hard enough to admit of being uncovered. The walls being thus gone round the next operation was to enclose the spaces between the beton blocks, and this was done by using the sides of the moulds, without the ends, and holding them in place by the following means: Two pair of pieces of scantling two by three in. each, and two ft. long, were set upright at the ends of the side boards, and bearing them against the beton blocks. At the middle of their length they were held by the rods and screws used in the moulds, and their upper ends being apart by sticks of the necessary length, the boards were thus clutched and kept in place. These inclosed places were now up flush in the same manner as the moulds, and by packing and tamping, the connections were rendered so complete as to make the whole a uniform mass. When each course was in this manner completed, the moulds were laid for a new one, taking care to break joint though no joint was visible, yet this precaution was taken to avoid any continuous joint or point of imperfect connection. Where doors or windows occurred, the moulds were placed correspondingly, one on each side of such opening; for it may be observed that there is no necessity for the fixing in of the frames until the work is all sufficiently set. However, it is necessary to insert these moulds at doors and windows, at the ends, which will form the jambs of such pieces of scantling called stops, four in. thick, and sufficiently wide to permit the future, frame to rest five or six in. back from the outer face of the wall. Of course the frame can be set up and the jambs worked up to it, but it is more troublesome and will scarcely make as good a job. The window-sills and caps were provided for in like manner, and there was a splay left in the window jambs, by means of angular pieces being added to the above mentioned stops, which gave the required mould to the beton. When the level of the ceiling was attained, the flooring joists were all set up in their places, and temporary bridging of plank fixed between every every pair, so as to hold the beton which was thus continued up, making a compact bed for the joists, and effectually preventing the lodgement of vermin. The short boards or pieces here used may be removed when the work is set, as they will be wanted again on the next floor. In the building we describe they were left in, but it is not at all necessary.

The joists being all flushed up with the beton, the floor boards were nailed down and the beton again flushed up to the surface of the floor. The moulds were now placed for the walls of the principal story, which being six in. less than than those of the basement, the ends of the moulds were made in accordance with the new thickness, namely, twelve in., and the work went on as before, with the exception of the corners of the main walls which were rounded by means of blocks of the necessary shape being set in the angle. This rounding off of the wall on the outer corners gives a very neat appearance without adding to the cost. On the contrary, it economizes the material; for the thickness of these corners instead of being greater on the diagonal, is exactly the same as that of the straight walls throughout. In the manipulation of the beton for the walls of the superstructure, it was deemed advisable to pack the front of each mould with a finer coat of cement than that used at the heart, or even at the back, so as to give a uniform face to the outside. This face was carefully troweled into the bed made for it in the mould, by working back the coarser beton in which the broken brick was packed. In the top of the first tier of blocks forming the course, an angle mould was laid along and pressed into the fine beton forming the outside face. And on the bottom of the next tier of moulds, a corresponding angle mould was laid and the beton cast firmly around it. And thus every course was treated. The consequence was that the cincture left on the removal of these moulds produced an effect on the exterior remarkably like coursed masonry, the course lines being of the > shape, about two in. wide, and one and a half deep. Other sections of cincture can be moulded to suit other designs of building. After each course was uncovered, these sunken mouldings were finished smooth by working a whole mould of the > shape along them, backward and forward. Perpendicular moulds of like shape might have been made to mark out each block, and no doubt would have improved the appearance of the building. The sunken horizontal courses were carried all around the house and produced a good effect. The next floor was flushed up at the joists precisely in the same manner as the first or principal floor. The windows and doors all set in and worked up to. But this is not the better way. The sills and lintels were of oak, but the latter did not show on the outside. It would be much better to have stone sills and lintels. The partition walls were six in. thick, and were cast in unbroken courses, with the exception of openings for doors. The door cases were set in and worked up to. Blocks were nailed to the floors at the walls and partitions, to receive the base board of the apartments—and these blocks were covered up in the beton. In like manner there were blocks inserted for nailing finishing of windows and doors to, and for holding the horizontal slates from which to hang pictures. The roof was a gabled one, of a fourth pitch, but a Nansard would have been a great improvement. The walls were skin coated on the inside of the house, and the best rooms were hard-finished. Nothing can be easier for the plasterer to make a workmanlike job with; for his material is sure to adhere to it. There is little more to add, save that the chimney-flues were all cast round by means of stovepipes used as moulds and left in. This is not a good plan, as the stovepipe will corrode after a time, and it is very difficult if not impossible to remove it. It would be better to use a movable cylinder mould with a handle, and have the flue finished smooth in beton. The chimney shafts can be very ornamentally finished with terracotta caps.

To those who can procure water-lime at anything like a reasonable price, we would strongly recommend beton as a particularly applicable material. It is warm in winter, cool in summer, and at all times dry and healthful. In mixing common lime with it —of course for economy's sake alone—it will be well to bear in mind that, whilst quick lime swells in slaking about one-fourth, water-lime on the contrary shrinks about a fifth. By experiment on the limes to be used, exactness can be attained. By thus calculating, the two may be, so to speak, dove-tailed into each other.

INDUSTRIAL PARTNERSHIP.

A humane tendency towards the improvement of the condition of the working-classes evidently exists in all civilized countries. Many systems have been invented and tried, and many have failed. The old French communistic principles have been found totally impracticable. No means have succeeded in England as yet to universally prevent great and long-continued strikes so ruinous to both capitalists and workmen. The idea of Lassalle in Germany that the "help" has to come from the governments, was not able to rouse the latter from their impassibility, nor to inspire confidence in the greater number of the workmen. The second empire in France undertook to calm the laboring classes by an unprofitable occupation, at the expense of the whole people, in the embellishment of the capital. This great and beautiful but to a great extent fruitlesss work is not yet fully accomplished, and already we hear of seditious scenes that occur in the embellished capital. In this country the vain attempt has recently been made to regulate by law certain relations between capital and labor, relations which under a despotic goverment only, could be regulated otherwise than by the free will of both the concerned parties, by voluntary agreement between free men and free men, between laborers and capitalists, when they acknowledge each others rights and when they recognize and own that the interest of the one is the interest of the other. The eight hour law was totally ineffective, as might have been expected before hand. A real and great success in improving the condition of the working-classes was, however, obtained in Germany by Schultze-Delitzsch, whom A. S. Hewitt in his report of the Paris Exposition of 1867, calls therefor "the greatest benefactor of the human race in our days." This system is based on the principle of "self-help" through associations of consumption, of work, of money, through education and enlightenment, inevitably followed by moderation and good sense. In other places may be read the accounts and statistics of the great number of societies for supply of materials, for co-operation for mutual credit, for acquiring a higher than the ordinary school-education, as they have been established among workmen all over Germany, especially under the influence and practical guidance of Schultze-Delitzsch. Great as this success may be, yet the question is considered in Europe where its solution is more urgent than here, of such a high and immediate importance, that new schemes yet continue to turn up and to be discussed. There is one amongst these which merits special attention because it benefits both capitalists and workmen, and because, to judge from the practical successes already obtained, it seems to be the proper way to perfectly unite in single instances the interests of both. It has been called "Industrial Partnership," and consists in giving to the workmen an actual interest in the business for which they work.

In a meeting of the engineers of the Lénne-district, held at Lethmate (Prussia) on the 12th of July, 1868, Mr. C. Kugel delivered a lecture on this subject from which we extract the following interesting remarks.

"In England where this system has originated, the motives which led to the first trial, were dictated to the capitalists not by humaneness, but by mere egotism. The relations existing between employers and employees in many districts were then such that the two parties stood opposite each other like two hostile armies, ready at any time to begin an open war. To alter this condition injurious to both parties, it was thought of granting the workmen a share of the profits, thus to inspire them with more interest for their work, thereby to increase and improve the production and to attain to the greatest economy in the manufacture. It was expected that carelessness in working would thus be checked or at least greatly diminished, because the workmen would mutually control themselves.

"The first trial with Industrial Partnership was made at the large carpet factories of Messrs. John and Francis Crossley at Halifax (Yorkshire). These works embrace an area of $18\frac{1}{2}$ acres of land and a capital of £1,500,000. They employ 4,500 persons.

Messrs. Crossley divided the whole of their business-capital into shares, the fifth part of which they offered and sold to their employees at £15 per share. By this operation they obtained not only perfectly satisfactory relations with the workmen, but a great material gain. Within the first three years after the introduction of this system, the yearly dividends amounted to 15 per cent, and a reserve capital of £11,284 was acmulated besides. In the greatest financial crisis the value of the shares of this company did not sink below £17. A success more brilliant yet was obtained through Industrial Partnership at the coal mines of Messrs. Briggs at Whitewood and Methley junction, near Normantown. Continual dissensions between the proprietors and the men existed at these mines from 1853 up to 1863. In the years 1858 and 1863, regular strikes took place. The proprietors in consequence concluded to sell one-third of their mining-property to their workmen, and to other persons in shares of £15, of which £10 had to be paid in at once. The workmen at first showed some diffidence. But very soon the demand for shares increased to such an extent from all sides that Messrs. Briggs kept in their own hand only 6,450 of the existing 10,000 shares. They sold 1,068 to their customers, 1,847 to the general public, 114 to their agents and 264 to their workmen; 230 more were reserved for further purchases from the latter. The office-employees took 86 shares, and the other 178 were sold to 83 miners and 61 laborers. As the works occupy in all 785 miners and 204 labores, one share is, in the average, in the hand of one amongst nine miners, and one share is in the hand of one amongst three laborers. No one, Messrs. Briggs of course excepted, can hold more than 6 shares according to the agreement. These mines which in former years in consequence of strikes and bad work, did not pay any interest whatever, have been able to distribute from £15,000 to £18,000 of dividends in the last three years and have besides accumulated a considerable reserve.

" The North-western Manufacturing Company in Chicago introduced the Industrial Partnership in the following manner. The weekly earnings of every workman were calculated from the average wages for a daily work of 10 hours. It was agreed that the whole body of workmen should receive in addition to their regular wages, the one half of the net profits exceeding 10 per cent of the capital. The distribution of these profits is effected in proportion of the wages earned by every single man, as found by the just mentioned calculation. The shareholders are to receive 10 per cent of the capital and the other half of the excess. According to communications received from Chicago, $50,000 of profits were obtained from one year's business with a capital of $250,000. The share of profits paid to the 140 workmen of the factory were therefore $12,500. Mr. Borchert, jun. in Berlin (Prussia) was the first German house who made a trial with the system of Industrial Partnership. Mr. Borchert estimated the value of his establishment at 300,000 thalers and divided this sum in 12,000 shares of 25 thalers each. He allows one-tenth of them, or 1,200 shares, to be bought and owned by his workmen and employees. The share-holders constitute a company for themselves. They elect three of their members as directors. The latter have the right to inspect the books, and they receive every month full information on the condition of the business from the proprietor who is also the general manager of the factory. As soon as three-tenths of the shares will be sold, the directors elected by the shareholders, will have a direct influence on the business transactions. One half of the net profits (probably after deducting a certain interest on the capital) is divided among the workmen in proportion to the wages received. These, however, who are steadily employed and paid by the week receive a greater part in proportion than those who are paid by the piece. The other half of the net profits is divided amongst the shareholders."

After having made these communications, Mr. Kugel in his lecture further alluded to the difficulties which in many places may oppose themselves to the introduction of Industrial Partnership. He thought however that, to judge from the brilliant success obtained with it in some establishments, it deserves to be warmly recommended. The introduction has of course to be done cautiously and with special regard to local circumstances. He finally expressed the opinion that the institution of Industrial Partnership will prove a better and safer step toward the solution of the so-called "social question," or the question of the improvement of the social position of the working-classes, than even the institution of productive associations.

We cannot conclude this article without directing the attention of our readers to a remarkable feature which some of the above mentioned examples of partnership have in common. The proprietors do not sell a certain number of shares to their workmen without selling at once a much larger number to outsiders. This appears to be an important point which prevents direct disputes between the shareholding workmen and the proprietors about the profits and the dividends. This remark does not of course, apply to those cases in which the proprietors, without selling any shares, distribute amongst their workmen a certain part of their profits as a free donation. S.

MAKING FOUNDATIONS IN MARSHES.—A new process of making foundations for bridges in marshy soils has been recently used on a branch line of the Charentes Railways Company in France. This line crosses a peat valley to the junction of two small rivers; the thickness of peat was so great that any attempt to reach the solid ground would have been very expensive. In order to obtain cheaply a good support for the bridge, two large masses of ballast accurately rammed were made on each bank of the river, and a third one on the peninsula between the two. The slopes of these heaps were pitched with dry stones, for preventing the sand from being washed away by the rain or by the floods in the rivers. Over the ballast a timber platform is laid; this platform carries the girders of the bridge, which has two spans of about 60 ft. each. When some sinking down takes place, the girders are easily kept to the proper level by packing the ballast under the timber platform; this packing is made by the platelayers with their ordinary tools. This simple and cheap process has succeeded quite well.

The same difficulty was overcome by a different plan on an ordinary road near Algiers. This road crosses a peaty plain nearly one mile broad; the floods and elasticity of the ground prevented the formation of an embankment. The road was to be carried over a viaduct across the valley, but the foundations of this viaduct presented serious difficulties, the thickness of peat or of compressible ground being nearly 80 ft. It was quite possible to reach the solid ground with cast iron tubes sunk with compressed air, or with any other system, but neither the implements nor the suitable workmen were available in the colony, and it was a great expense to bring them, and especially the workmen, from France. The use of timber piling was of course out of question, as timber is very expensive in Algiers and quickly becomes rotten; but there was a set of boring implements with the men used to work it. The engineers began boring holes 10 in. diameter down to the solid ground. These holes lined with thin plate iron pipes were afterwards filled with concrete up to the level of the ground. Each of these concrete columns bear a cast iron column; these columns are properly braced together and support the girders of the viaduct which is divided into spans of about 20 ft. and is 20 ft. high over the ground. This system has succeeded very well, and is to be extended to another larger valley.—*Cor. The Engineer.*

STEAM AND POWER HAMMERS.

From a paper before the Civil and Mechanical Engineers' Society, by Mr. FREDERICK H. ROBERTS, C. E.

The author referred in detail to some of the earlier machines, such as the helve or tilt hammers used for shingling, forging blooms and shafting, tilting steel, etc., but as this class of machine depended, to a great extent, for raising the hammer and its connections, either through the direct medium of cams, eccentric, or similar arrangements, it followed that the power required to work them was extremely large, and the parts of the machine itself very heavy and cumbersome to withstand the consequent strains. It was also found that the larger the mass of metal to be worked, the lighter the blow given, and, conversely, the smaller the mass, the heavier the blow; it was, therefore, ill adapted for heavy forgings. The invention of the steam hammer solved the difficulty which was found to exist, and to it, to a considerable extent, is due the perfection obtained in all classes of machines where ponderous forgings are found to be absolutely necessary.

The first idea with reference to the steam hammer the author traced as belonging to that great engineer, James Watt, who obtained a patent, in 1784, for heavy hammers or stampers, for forging iron, copper, or other metals without the intervention of rotative motion, by fixing the hammer head either directly to the piston or piston-rod of the engine. Another patent followed this in 1806, by a Mr. Deverell. He proposed to admit steam underneath the piston of an engine by means of a valve, and during its up-stroke the air at the top of the piston was compressed by the pressure of steam beneath, which was released at the proper moment. The compressed air on the top of the piston, in addition to the gravity of the hammer head, was to give the blow. But neither of these ideas were put into practice at that period, and it was not until 1837 that any practical design was put forward for a steam hammer, and then by Mr. Nasmyth, of Patricroft, who urged its superiority for working metal over all other machines, but was unable to procure its adoption until about 1840, when he found that M. Schneider, of Creusot, profiting by his design, had constructed a machine on his plan. In 1842, he obtained a patent for his steam hammer, and from that time it became a recognized power, and a necessity in all works of importance. The facility which it afforded for executing all kinds of forging had the effect of greatly increasing the quantity of work to be done, and effecting a material saving both in time and labor.

The steam hammer, as originally constructed, required the valves being worked by hand, which left the machine in the power of the workman to give proper efficiency. The valves were also very difficult to work. This plan answered for the time for small machines, but where rapid motion was necessary, and for larger hammers, it was unsuitable. Several designs for self-acting motion, therefore, followed in quick succession. The author then referred to the different designs that had been introduced for this purpose. In the ordinary self-acting hammer, the man has to watch the metal under operation, and, as its form and position change, he must set his valve gear to suit as near as possible. The author considered that the motion, to be properly self-acting, should be independent of the workman as regards the adjusting of the gear to suit the varied thicknesses of the metal on the anvil; and, in order to obtain the full force of the blow, it should reverse simultaneously with, or immediately after the blow is given, and at whatever point in the stroke the blow takes place. He considered that was accomplished in Sturgeon's double-action hammer, where the blow itself was made use of as the agent to work the valve, and described the mechanism employed; also the various types of double-action steam hammer; likewise the numerous modifications and improvements effected. The author then spoke as to the specialities of the heaviest classes of steam hammers of modern date, including those of Mr. Ramsbottom's design; likewise those erected for M. Krupp, at Essen.

With reference to machines of a lighter class, the author described the various designs for power hammers, and referred to the patent pneumatic hammer, several of which he had erected, and which are specially adapted for general smithy work, or light forgings, planishing and beating out metal, etc. It is extremely simple in action, working by means of the alternate exhaustion and compression of air within two cylinders, in one of which is a piston, to which the hammer head is connected by means of the piston-rod. By opening a small valve, the vacuum formed within the cylinder is destroyed, and the blow weakened or stopped instantly, according to the amount of the valve opened. The machines are capable of working up to 500 blows per minute when required.

IRON-FOUNDING.

UNITING CAST-IRON BY "BURNING-ON."*

From the "Practical Mechanic's Journal."

Connecting lead with lead, by running a stream of very hot liquid lead, suitably confined, in contact with a surface of solid and cold lead, until the latter had got to its melting point, and then stopping the current, so that the two portions become united when both solid, has been known to plumbers for ages under the name of "burning together." In fact, by this method some of the earliest lead water pipes were made before "drawn pipe" was known.

This same method of "burning together" may be also employed by the iron-founder, and occasionally with great advantage. The writer, in the course of his early practice, had occasion to cast four of the very ponderous columnar cast-iron frames which, in the earlier days of steam navigation, were to be employed for the "side frames" of side-lever marine engines of the heaviest class. The frames in question consisted of coupled Roman-Doric columns of considerable diameter, cored out, with cross framing and entablatures, also all cored out, and with sundry projecting pieces like truncated horns etc., whereby the frames were to be united

* See also Van Nostrand's Mag., No. 8, page 705.

with other "thwartship" pieces, each frame weighing several tons and consuming a large amount of wages in moulding.

All four were cast sound and without a blemish, except that, upon the top box in which one of these was cast—all being cast in green sand—some one had unluckily dropped a bar or something heavy, or put a foot upon it, and produced "a crush," which rendered one of these horns utterly amorphous. The casting, otherwise perfect, was in that state absolutely useless, and was about to be broken up, when the writer resolved to try and save it by attempting to "burn-on" a new and perfect horn. The old and defective mass was carefully cut off, and removed down to absolutely sound metal. "Loam cakes," having the proper form for the horn, were taken from the pattern, the surface of the cut metal was well dusted over with powdered glass of borax, after that the mass of the "frame," in close propinquity with the defective place, had been heated red-hot in a coke fire built up around it. The fire was then raked away, the loam cakes secured in place, and several hundred weights of very hot liquid cast-iron were for some time kept flowing through the cavity of the loam cake hollow-mould. At length the flow was stopped, when the cut surface could be felt, with the point of an iron bar pushed through the running metal, to have become pasty and soft, and the iron was then permitted to set. When finally stripped and "gaits" etc. removed, the new horn was found to be perfectly united with the remainder of the casting, and when struck it gave the clear sonorous ring which proves complete metallic continuity.

The success, in fact, was perfect, and somewhat surprised both the writer, to whom so large an instance was new, and the marine engineer responsible for the supervision of the work, who would not pass the casting until he had assured himself of the safety of the horn by striking it heavily with a sledge-hammer. This method is capable of being applied not unfrequently with similar ends in view, and may often save the condemnation of a casting and effect a good deal of economy. It can almost always be made effective, if the methods be judicious, for attaching, as in the above case, a heavy piece to a heavy casting; but it is a far more delicate and difficult task to make succeed with smaller and more delicate work, and there are two generic cases in which it is useless to attempt it.

One of these is where the form or dimensions, or both, of the casting must remain *precisely* the same after the work as before; as, for example, if a piece be defective in the rim or in one of the arms of a large spur or head gear-wheel, there would be no great difficulty in replacing it soundly by casting together as described; but either the wheel would crack somewhere on the setting of the "burnt-in" metal, or during its cooling, or it would have lost its circular form and "truth" when all should be cold.

Again, if the mass of casting be very great, and it is but a whole or cavity, regular or not, that requires to be filled in with metal, which must be perfectly united with the remainder, this can scarcely be accomplished unless at an expense that renders the process worthless; for *the whole* huge mass must be brought to a strong red heat, with great expenditure of fuel and time and surface injury to it by oxidation, or the union will prove imperfect. Such has been the fate which has always attended attempts, thus to restore defectively cast cylinders for hydraulic presses. The writer, however, has little doubt but that a sort of small coke-fed furnace, with a strong blast, delivering from a small brick-lined mouth a jet of flame like that of a large blowpipe, might be so used as to heat even up to the melting point—and but very locally or partially—any mass of cast-iron, however huge, so as to admit of "burning on" to it. He once witnessed sufficient proof of this in the method taken to repair a defect which appeared in the neck of a very heavy cranked intermediate shaft for marine engines, at the Thames Iron Works, just before Mr. Mare ceased to direct them. The neck of the crank, about eighteen in. diam., was rough-turned, when a hole was found and cut into in the forging, close to the angle of the neck where joining with the arm or side of the cranked part. Nothing could be more awkward as to position, and the condemnation of the whole forging, and serious loss, seemed imminent. The foreman blacksmith determined upon one trial to save it. He got up just such a coke-fed giant blowpipe as has been described, and drove its flame right into the defect or cavity, having carefully "clayed up" the iron of the rest of the crank adjacent, to save it from oxidation.

In about five hours he had the interior of the cavity at a fine uniform and clear welding heat. A piece of wrought-iron, well-judged—as to form—to rather more than fill it, had been got ready, and at the right moment was brought, in a forge-fire, to a welding heat also; and the blowpipe blast being thrown off, the welding hot plug, preceded by a dust of sand and borax glass, was thrust against the cavity, and a single blow of a "tup," beforehand properly swung ready, sufficed to firmly weld it into place. The superfluity, when cold, was chipped off, and the turning of the neck completed, which the writer witnessed; and he can testify that it was not possible upon the clean cut surface then to discern where was the new iron, and where the surrounding old of the original forging. The work reflected much credit upon the skill of those who conducted it, and in that respect alone deserves to be recorded. The method of heating, however, is quite as applicable to cast as to wrought-iron.

The marine-engine framing above referred to was treated about 1833. In the "Annales des Mines" for 1860, M. Mengy gives a circumstantial account of the same method having been applied about the same date at the Tamaris Iron Works, Departement of Alais, to burning-on the broken-off necks of the iron rolls of the rolling mill, and with complete success. Dr. Percy ("Metallurgy," p. 745) states that he has seen a roll thus repaired at the Millwall Iron Works, and that the method has been in occasional use elsewhere.

Dr. Percy also gives an interesting account of the Chinese method of mending or stopping holes in their very thin cast-iron rice bowls or boilers, when broken through these brittle vessels, by means of a plug of pasty cast-iron adroitly applied by the native "tinker." He cleanses the edges of the hole, melts a sufficient large bit of cast-iron in a small crucible, in a little charcoal furnace, tilts the liquid iron out upon a folded damp cloth spread with ashes and held hollow in the hand, and at the moment before the cast-iron assumes the *pasty state* just before "setting," he thrusts it up to the outside of the hole and through it, and smoothes the overplus at the inside with another like cloth; so that he has thus made a sort of irregular rivet of the semi-liquid material. There is here, however, no metallic union. The case is precisely analogous to the manipulation by which the plumber makes a "wiped joint," applying the semi-liquid plumbers' solder, held in the hollow of his "tickenfelt," rapidly and adroitly to and around, the shaved and tallowed surface of the adjacent ends of the lead pipe to be united; and equally analogous to the way that holes in earthenware vessels are sometimes mended in this country, by a semi-liquid rivet of fusible metal quickly pushed through and smoothed over on both sides. It is not impossible but that more extended uses of this same method and of the analogous properties of cast-iron, though at its much higher temperature, might be found if looked after.

Where a mere cavernous defect exists in castings which injures appearance only, and which may be filled up level as sufficient remedy, cast-iron is very often dropped into the hole and the surface instantly scraped or cut off level by shoving an iron straight-edged scraper across the mouth of the now filled-up hole. This, however, is seldom a very neat method of repair, and some iron-founders adopt for the filling material an alloy which is almost identical in color with the dark surface of freshly-made castings, but is much more fusible than cast-iron.

This alloy is said to be best composed as follows:

Antimony	65	
Copper	16	
Lead	13	by weight.

Some prefer—

Antimony	69	
Copper	16	
Tin	2	
Lead	13	by weight.

The copper, tin and antimony are melted together first, and the lead then added.

Where, for such operations as are above referred to, defective or other parts of castings, more particularly of large size, require to be cut off, if there be suitable appliances at hand, they are much more easily removed at a cherry-red heat by means of a rapidly rotating circular saw, as in cutting off the ends of rolled iron rails, than by cutting away with machine tools or by hand, cold. Indeed, in many ways besides this, cast-iron is an extremely tractable material at a low or cherry-red heat. Thus, for example, at that temperature, castings which have been molded flat may, if need be, be curved by bending over a saddle of suitable form and to almost any extent.

Or curved pieces, buckled in the cooling, may be forced back flat, or the curvature of pieces, which have too much departed from that of the model, by contraction in cooling, may have their curvature corrected, etc.

The writer once cast a great number of very thin perforated flooring plates for a bridge, which were required to be curved into arch plates. They were cast quite flat, which, owing to peculiarities of form and perforation, was found the best plan to secure soundness, and then curved by bending over a saddle of baked fire-clay; for the saddle must not be of good conducting material, or the casting gets chilled and possibly broken.

Blackfriars New Bridge.—When one of average imagination, distant foreign travel, and general reading, sits down to write about the last important bridge that has been built in this country, he cannot avoid a dream-like glimpse at bridges everywhere; the natural bridges of South America, with earthquakes for their engineers, contractors, and workmen; the many thousands of primitive bridges in China, formed of huge slabs of stone, brought in many cases from immense distances by human labor; the numerous interesting bridges in France, Germany, Switzerland, and other parts of the continent of Europe, not to speak of the triumphs of this generation's engineers in overcoming almost all conceivable kinds of difficulty in bridge construction that could be presented by climate, materials, situation, or other circumstances in every quarter of the globe. * * *

Blackfriars bridge is altogether formed of wrought-iron so far as the main structure is concerned—the embellishments only being of cast metal. Preparatory to the actual commencement of this important undertaking, the erection of a temporary wooden substitute, as well as the demolition of the old bridge were necessary. The first piles for the requisite gantry—one-third of which is now removed—were driven in, June, 1864. As it is generally considered in the London district that the London clay must be reached to obtain a sure foundation for large buildings, this course was here followed, involving three or four months of incessant daily and nightly anxiety and labor—on account of the tides. For our part, however, we coincide with the opinion of some eminent practical engineers, that there is no absolute necessity for going down to this clay, and that consequently, in doing so, much needless expenditure of time and money is incurred. The bridge consists of five arches, namely, two of 155 ft. span each, two of 175 ft., and one of 185 ft. The height of rise in the center arch is 17 ft., and in the others 16 ft. and 12 ft. respectively. Instead of regularly-framed centring, piles were driven down to support the ribs where required, which doubtless saved the contractor much expense both in erection and demolition. The ribs were then wedged up to the soffit of the arch; these wedges or slacks are now removed, so that each arch rests on its own skew-backs, and the piles can be taken away at once. Mallet's patent buckled plates, which, as most of our readers know, are made of about $\frac{1}{4}$-in. plates of iron placed heated over a mould and stamped by hydraulic pressure into the shape of a groined arch, are bolted to the roadway bearers by $\frac{5}{8}$-in. rivets, and form an immensely strong platform. On this is put one inch thick of asphalte; over this again—an addition to and improvement on the usual practice—a layer of broken stones and asphalte, from 9 in. to 12 in. in thickness, is placed; and lastly, on top of all, is granite pitching as ordinarily laid on roads. The total length of the bridge is 1,272 ft.; its width, including the roadway of 45 ft. and two footpaths of 15 ft. each, is 75 ft. The gradient is 1 in 40. There are eight polished red granite columns, between which there are parapets 3 ft. 9 in. in height. Over each column there are recesses in which there are seats capable of resting ten or a dozen weary pedestrians. A handsome row of lamps will be placed along each pathway, a little back from the kerb—a plan not adopted on any other of the Thames bridges—and they will be so arranged as to facilitate the navigation after dark. The balustrades are Venetian-Gothic in design. They were beautifully cast by Messrs. Lloyd, Foster, and Co., at their works in Wednesbury, Staffordshire, and will form an elegant adornment to the broad York stone pavement. This, with the Thames Embankment, which will meet the bridge at the north abutment on the same level, will form a promenade, on which, no doubt, the ghost of Dr. Johnson will vary his "walk down Fleet-street," and which will prove a source of health and recreation to the pent-up denizens of the City. Viewed from the river, either in ascending or descending the stream, Blackfriars Bridge will present a fine appearance with, as will of course eventually be the case, characteristic groups of statuary to crown the abutment piers, capitals on the polished granite columns, representations of sea-birds and plants on the east, and of their fresh water prototypes on the west façades, finished by the sky line of the chaste parapet, relieved at intervals by the handsome lamps.

The cost of the erection and maintenance of Blackfriars Bridge will be defrayed from the funds of the Bridge House Estates, the revenue of which is some £40,000 per annum, and to which £21,000 will fall in, in a couple of years, from terminable annuities, on which money was advanced by Government for the building London Bridge.—*The Engineer.*

THE GREAT BRONZE FOUNDRIES OF FRANCE.

From "The Practical Mechanic's Journal."

The casting in bronze, as the chief amongst several metals or alloys by which the artist can endurably entrust the conceptions of his imagination to a remote futurity, mounts as an art to the very earliest yet known origins of our race. China, India, Babylon, Egypt, Greece, Rome, the middle ages of our Europe, the Renaissance, and our own day contribute their monuments or testimonies of this. And yet, in some senses, the art has never spread, or become a diffused or universal one; at this moment there is really but one great bronze-casting nation in the world—France.

England has not been absolutely without attempt to establish bronze-foundries of works of art; but while we have dozens of brass-foundries existing chiefly as integral parts of our great engineering establishments, in which heavy and light bronze or brass castings, for parts of machinery etc., are made in great perfection, there really does not exist, we believe, in Great Britain a single bronze-foundry devoted solely to the speciality of fine-art castings.

Nor are we likely soon to see such, for a great foundry of Bronzes, as objects of high art, demands the combination of two classes of industrial ability, only one of which we, as a nation, can command from amongst ourselves. We must obtain the respective manual skill of the moulder and founder, and, in addition, the hand and eye and genius of the modeler and the metal-chaser; and we may add, above all, that generally advanced and educated standard of taste amongst our people, more especially of the wealthier classes, to appreciate and reward their combined efforts. This combination, of distinct but closely allied and mutually helping talents and powers, can never be broken up and yet success await the issue.

It is for this reason that, while we have had Bramahs (the younger), Robinsons, and Cottams etc., spasmodically attempting the art, and indeed making very fair castings—merely viewed as such—and have had (to say nothing of divers "men in brass jackets") colossal lions, moulded by a painter and cast by a marble sculptor, we have never yet produced a first-rate group in bronze; nor ever established artistic bronze-casting as a fine-art industry amongst us. The Bramahs and Cottams etc., were mere moulders, brass-founders; the Marochettis, whatever they may have been as sculptors, were trading speculators in casting statuary; an art of the refinements and details of which they personally knew nothing, and for the execution of which, in their pompously styled *ateliers*, they were dependent upon the hireling skill of workmen, who well knew the practical ignorance of their employers.

Prussia and Austria—especially the former—have been a good deal more successfull; and almost wholly because they could command the poetry of art, and bring it into the foundry, which we cannot do. And perhaps there is no single modern monument of fine-art bronze-casting in Europe or in the world, at present, of nobler conception and execution than the grand equestrian statue of Frederick the Great, with its surrounding figures and colossal base, on the Linden at Berlin.

Russia, too, has had her long-descended line of first cousins to bronze-founding in the men who cast the gigantic bells of the Kremlin, and her huge old bronze guns; and their descendants have produced some very noble statue-castings, such as the Colossus of Peter the Great, and a good many very finely-cast statues of smaller size, such as the horses and horse-tamers presented to Ferdinand of Naples by the late Emperor of Russia, which are over the piers of entrance to the Palace garden at Naples.

But all these have been spasmodic efforts, sporadic results; in France alone has artistic bronze-casting taken firm root, not as an appanage of despotic extravagance, but as a noble and genuine branch of industry. It would almost seem as if this Roman art had descended to the French, as certainly the lineal successors in many respects of Rome, and the people over the face of whose country Rome spread more widely and choicely the education and the solid monuments of her civilization, than over any other area in Europe. This, however, would be but a fancy: the expansion and success of fine-art bronze manufacture in France, and, *par excellence*, in Paris, has really been due to the art-loving genius and impressionable imagination of her people, to their art-education, long continued and well understood by those who have conducted it in successive decades; and to the patience and *habileté* of her workmen, supported and empowered by the genuine knowledge and metallurgic science of those who lead them.

On the whole, brass and bronze-founding is much more of a speciality in France, in all its departments, than it has (hitherto at least) ever been in England. We do not make any reference now to Government foundries, such as the bronze gun-foundries of France or of England.

There are, however, in France, great establishments—such as those of M. Voruz, at Nantes—engaged wholly in bronze and brass-founding, and with special departments for artillery, for casting for mechanical purposes, and for statues and other objects of architecture and of art; all being, though of course with the usual fluctuations of trade, kept constantly at work. We are ignorant of a single like establishment in Great Britain. Paris is, however, the great head-quarters of fine-art brass and bronze-casting, and practically supplies the world with its productions.

We view, as out of this trade altogether, the very numerous, and, in a trade-sense, important brass-foundries of Birmingham and its neighborhood, engaged upon small objects for house or domestic or other use, and which profess to have more or less of ornamentation, but certainly have but small pretensions to art, in any worthy sense. Nor do we refer to Japanese bronze and brass work, further than just to remark, that while objects of considerable, some of great, antiquity brought thence formerly by the Dutch, and more recently by ourselves and other European nations, prove that at some anterior epoch, artistic bronze manufacture had reached a very noble perfection, and great peculiarity and often beauty of treatment in design, more modern examples equally prove that the art has greatly deteriorated amongst that wonderful people, or that we now receive from them none of their best examples of art.

No English person who has been a day in Paris can have failed to be struck with the profusion of bronzes in the public ways, in the buildings public and private, and in the shop windows. Bronze-casting is, in fact, a great industry there. There are probably not less than three hundred houses engaged in the trade in one way or other; but of these there are no more than perhaps about fifty who are actual manufacturers, and of these again not more than about twenty who stand in the first rank, of ability and eminence, either as conducting some one or more special branches of the *bronzes des beaux-arts* trade, or the whole of them. But although thus the finished objects of the Parisian bronze-founder arrest the eye and glitter before us at every step upon the Boulevards or in the Palais-Royal, next to nothing is known generally, not even to the technical or metallurgically-skilled visitor to Paris, of the establishments whence these beautiful and costly objects issue, or of the apparatus and methods by which they are produced. They are, in fact, sealed, rigidly shut against all intruders, and for many good and sufficient reasons, which do not admit of being regarded as the mere offspring of narrowness, timidity, or jealousy. One only we need mention. The workmen are, in each of several classes, specialists, in a sense the most absolute, and French employers have found that unworthy and unscrupulous means to detach these men and bring them elsewhere, have been but too often practiced by those to whom the grace of *entrée* may have been accorded.

We have heard, though we do not at all intend to suggest, that, in this way, fine-art bronze-casting in Belgium and in Germany has been very much advanced by the introduction of French artisans.

In Italy most of the workmen, in such establishments as that of Signor Clement Papi, which produced the largest bronze statue, that of the David of Michael Angelo, in 1867 at Paris, are natives; but we believe this is not the case in Prussia, Austria, or Russia.

So far as we are aware, no literature exists which treats in a detailed or practical way of the methods and apparatus of the fine-art bronze-foundry. We shall find none whatever where we might have expected it, viz: in the volumes of Reports of the French Imperial Commission of the Exhibition of 1867, or, indeed, in the reports of any preceding one. The reporter for 1867, on class 22 (Vol. III, of the collected reports) was M. Barbadienne, the man who perhaps, above all others, *could* have given us a complete and invaluable treatise upon the technicalities of this manufacture, in which he has so long and so conspicuously led the advance. We look for any such details in vain; not that we imagine M. Barbedienne felt the slightest desire or ground for reticence, but that the space assigned him in these volumes as a reporter was far too restricted to admit of his dealing with more than mere generalities; indeed, the whole 500 pages of Vol. III might prove less than enough to enable, one at once so skilled in every detail, æsthetic and technical and so enthusiastic, to pour forth the treasures of his knowledge upon this speciality, in which he so admittedly leads.

Where no literature exists, therefore, a sketch may be accepted as a not unwelcome installment. Such we are enabled to give, the writer having been recently accorded by M. Barbedienne himself the unusual and special favor of the unreserved examination of his noble foundry and manufactory at Paris.

There are, no doubt, half-a-dozen fine-art bronze-foundries in or about Paris, the description of any one of which would prove interesting. That, however, of M. Barbedienne stands amongst these *facile princeps*, and indeed is not one, but, so to say, a congeries of special manufactures. The works are situated in the Rue de Lancry, at not a very great distance from the well-known "show shop" of bronzes, as our homely phrase is, No. 30 Boulevard Poissonnière. It is, however, happily placed, though still upon the edge of that quarter of fashion, traffic, and pleasure, also upon the border of that wonderful north-east quarter of Paris, which, like our own north-east of London, is the seat of so many of its myriad industries, and which, as respects the French capital, is a *terra incognita* to ninety-nine out of the hundred Englishmen who visit that city, or even reside in its fashionable quarters.

Entering from the street, we pass through a range of offices, waiting-rooms, packing-rooms and stores, and find ourselves crossing a yard, and at once in the large bronze-foundry.

The establishment comprises, in fact, the following departments if we may not almost call them distinct manufactories:

1. The bronze-foundry and its accessories.
2. The chasing-shop—*galerie des ciseleurs*.
3. The shops for the production of models, and for the completion of a large number of these in the permanent material bronze.
4. The marble work; a complete establishment for the working, both by machine tools and by the sculptor's hand, of all sorts of marbles, onyxes, and other fine and hard minerals.
5. The shops for mounting of Carcel lamps and other objects of artistic bronze work in combination with porcelain, glass, etc.
6. The enameling shops, in which that peculiar form of "*émaux cloissonnés*" which, dating from Byzantine art originally, had been lost to practice for ages in Europe, though always employed in China and Japan, and were revived in France by M. Legost, in 1855, and greatly extended by M. Barbedienne.
7. The "*atelier*," in which the delicate and beautiful machinery of M. Collas is worked for the automatic reduction or enlargement of solid forms.

This machinery is constantly employed in the production of new models for bronzes, etc., whether figures or bas-reliefs, etc., and of every size. It constitutes, as M. Barbedienne has himself affirmed, the right-hand of the bronzist, enabling him not only to reproduce the forms of ancient art with rigid exactitude, but to copy them equally so to any scale, and at an extremely small cost.

Were it not for this machine-tool, it would be impossible, at any reasonable prices, for M. Barbedienne to quote in his catalogue sometimes as many as eight different sizes for the same reproduced antique statue, and to have at command five or six sizes in bronze of nearly all the celebrated statues, ancient or modern, which enchant the world.

M. Collas' machinery gained him, and we believe very justly, the grand medal of honor at Paris, in 1855. Its rudiments, however, are very ancient, and to be found in many an old book on turning; and in reality we believe there is little doubt but that all which M. Collas has effected was done, and thoroughly well done, by Cheverton in London as early, perhaps, as 1830; as those who have seen, or are happy enough to possess, specimens of his matchless reproductions to a reduced size, in ivory, of the antique bust of Clytie, must be aware. Cheverton, however, worked his machine in secret in his chamber, and would not divulge its details, and we believe died without having ever fully and publicly claimed to have been its perfector.

What degree of similarity there may be between both we cannot say, but all machines of this class in reality depend upon the use (more or less implicated, of course) of a lever, the ratio of whose arms is variably at will, one end of which carries a dumb point which traverses, in closely and equally adjacent parallel lines, over the contour to be copied; while the other end, guided by that, carries the revolving or other cutting tool which removes the brute matter from the mass, to be formed into the reduced, or equal, or enlarged copy, and can remove no more.*

8. Besides all these there are "mounting shops," where the bronze pieces are connected, either with precious marbles or stones, or by "*menuisiers-ébénistes*" with fine cabinet work.

Subsidiary to all these there is a grand gallery or store, for porcelains, Indian, Japanese, French, English, etc., to be employed for divers ornamental ends in combination, and a whole tribe of small shops for the preparation and repair of tools, etc., etc. We need scarcely say amongst these are "drawing shops," artists' studios, in fact, where the imaginative brain labor that inaugurates much that follows, is in full play on the part of architectural and sculptural draughtsmen, and other artistic "*coopérateurs*" of the establishment.

Let us return to the foundry and its adjuncts, of which we can describe much to interest our readers, without any breach of the confidence reposed in us, as visitors to these famous works.

The foundry is a very large rectangular brick building, whose sides are about twice the breadth. It is lighted by ample skylights in the roof, and we at once notice the perfect cleanness of the walls and roof, and the nice clear pearl-white with which the brick of the former is colored, so as to afford the best light without distress to the eye. There are no piles of rubbish about, neither spare-boxes, nor unused models; all is orderly, a picture of neatness.

The floor, with the exception of some gangways, is of loamy sand, and ready in heaps beside each moulder.

The greatest proportion of the work being small, or very small, so the whole (nearly) of the moulding work is done on benches.

These occupy a large proportion of the whole area, and are arranged transversely to the length of the building in parallel ranges, with an axial gangway passing right through, and dividing them along the center. Each bench is double, *i. e.* two benches and two sets of moulders face each other at work. Each bench varies in width from $3\frac{1}{2}$ to perhaps 5 feet; and the mid-line of separation between the opposite benches of the same double bench is occupied by a raised division, with a low table or shelf on top to hold tools.

By far the greater portion of the work is moulded "in dry sand," the large statues being in true "loam work," but "green sand" moulding for small, plain, or unimportant objects is also largely practiced.

At one side of the "*salle*" is the place where the sand is prepared, mixed and damped. The sand employed is of two qualities, one being of a deep brown color, and very loamy; the other of a very light yellowish-white, with more yellow particles *parsemé*. Both are obtained at Fontenay des Roses, not far from Paris to the northwest. The two sorts are mixed, first, by interstratefying them in alternate layers in heaps, the relative thicknesses depending partly on the class of work the sand is being prepared for.

These zebra-striped heaps are then cut down with the shovel, and the whole set between a pair of very fine set horizontal cast-iron rollers. The sand is finally, after being damped to the right degree, sifted, and so handed over to the men. The "*chassis*" or moulding-boxes are all of cast-iron, very carefully fitted together, and with well-planed edges. We did not see a single wood-box* (so common even now in British brass-foundries), nor any makeshift of any other sort about the establishment.

Wood patterns or models also are but little employed, except for objects to be finished in the lathe. The models are chiefly of bronze, carefully chiseled or chased up, and given a dull brownish-grey sort of "patina," which seems to enable them to part from the sand with very great cleanness. Plaster casts, fusible metal, wax, and even occasionally porcelain or glass come into play as models also. All the bench moulding-work is of a character demanding great care, dexterity, and patience. The latter quality, as well as steadiness of hand and perfection of vision, find their greatest demand with the moulders who are engaged in casting objects which are to form the basis for the *émaux opaques et cloisonnés*.

* Blanchard lathe.

* "Practical mechanic's" name for "flask."—Ed. V. N.'s Mag.

Our readers generally are, no doubt, familiar with the character of these from seeing the like objects exhibited in Chinese and Japanese collections. The design, always of a stiff and conventionalized character, is outlined, as it were, and its distinct portions divided by very thin walls of bronze, mere lines almost, which rise square up from the general surface of contour of the object, and to a height equal to the depth of the intended coat of enamel, which is very thin, not more even than a millimeter, seldom more than half as much. Thus, in fact, the enamel when baked in, is held fixed in so many shallow bronze-surrounded cells, the dividing and adjoining edges of which are polished off bright, at the same time that the enamel is ground off to a uniform surface. This little digression may serve sufficiently to explain the nature of *émaux cloissonnés;* and into the details of the compositions of the enamels themselves, and how applied and completed, we do not here purpose entering.

It will thus be seen that the very utmost importance attaches to casting these little *cloisons*, or cells, perfect; any morsal of bronze improperly filling a portion, however slight, when cast, has to be cut out by hand, and at some risk of damaging the thin low wall of the *cloison* itself.

It is almost painful to watch the lynx-eyed patience with which the moulder of one of these objects—say, a huge vase of three feet in hight, covered all over with thousands of these cells—finishes each, with minute almost microscopic hand tools, after he has "drawn" the bronze pattern. The value of this is represented mainly by the money consumed in payment for the design, the original wax and plaster model, and the casting and hand-finishing of this workable bronze pattern; such patterns are laid aside on cushions, and kept covered carefully.

We shall not devote space to describing the considerable system in operation for the organization, registration, preservation, cleansing, and return into store, of the innumerable patterns. The law of copyright, which in France is far more protective and precise than it is with us, has greatly relieved such men as Barbedienne of one of their anxieties, viz: that of having their design stolen, or their models bought for patterns by others; still, the *chefs d'œuvre* are guarded with care.

The facing sand of the moulds, whether dry or green, is prepared with a mixture of charcoal dust and of potato starch, or of wheaten flour of the very finest grinding. In the preparation of these each moulder takes his own way, and there appears to be as much whim and variation here, as amongst iron-moulders. Sand cores, amply hollowed for air, are employed for all hollow objects, not of large size or not cast in loam; for the latter, the cores are also of loam. In statue-casting it is deemed of high importance to the final perfection of form when cast, that the thickness of the casting should be perfectly uniform. This arises chiefly from the great contraction in cooling (from 1 to 2 per cent) of bronze, and the prolonged state of plasticity through which it passes between the liquid and solid states. Hence, if there be thick parts as well as thin, the latter solidify so completely before the former that the thick parts get more or less distorted. The distortion may be utterly invisible to the undisciplined eye, but that of the artist-workman here readily detects and finds fault with a change of form in the muscles of a "*Discobalus*" or a "*gladiator*," or in the voluptuous rounding of the limbs of a *Vénus accroupie*" or "*de Milo*," which the world at large cannot discern.

The contraction of cooling is found to augment in ratio, with the size of the object cast, being greatest in large statues. For all these reasons, the utmost care and some very refined, though simple, methods are employed to ensure that "the core" shall be in form precisely similar to the exterior of the statue or figure, and that it shall be placed and fixed in the mould with rigid concentricity. It is the opinion of M. Barbedienne, which he has expressed in his Jury Report (Class 22) of 1867, that wheaten flour is not so good a facing material as charcoal dust; but he deems that much remains to be learnt as to the best material for facing bronze sand-moulds, and hesitates not to say that no moulder now-a-days succeeds in attaining an equally *fine and uniform granulation* of surface as was habitually produced by some of the great bronze-founders of older days, such as Richard, the Ecks, Durand, and the brothers Keller, who cast so much for Louis XIV.

It is also worthy of memory how fully M. Barbedienne insists upon the primary importance of perfection in the moulding and casting. Most persons would say that an object which was to pass into the hands of the "chaser," or *ciseleur*, might be cast as rough as we please, and yet all its faults be remedied in the metal-sculptor's hands. Skilled experience says no; it even goes so far as to say, if the work come out of the sand perfect, the less the "chaser" does to it afterwards the better; and, in fact, M. Barbedienne boldly attributes the matchless beauty of many antique, or even middle-age bronzes, to the fact that in these, the same mind, eye and hand carried through the entire process, from the conception of the model to its completion, thence to the moulding and casting, and finally to the chiseling and dressing, and to complete finish.

This seems to have been true in some cases at least, if not in general. The exquisite bronze statuette of the young man, found about five years since at Pompeii, which has been called, though on no sufficient evidence, "the Listening Hunter," and which is undoubtedly one of the finest reproductions in the world, to reduced scale, of the youthful male form, as well as several of the great *relievo* castings of mediæval Italy, in gates and well ("*pozzi*") curbings, are cases in point.

But to return; at the end of the foundry, furthest from the entrance, are the furnaces, the stove for drying the moulds and cores, of which we need say nothing but that it is heated by the waste furnace-heat, and a large wrought-iron jib crane for pitting and unpitting boxes in which large objects are cast.

The bronze for all moderate-sized objects, say up to 250 kilos., is melted in clay crucibles, which are made in the neighborhood of Paris, and hold about 30 kilos. each. These are not extremely refractory, but stand three or four meltings.

There are eight crucible furnaces, in form very much that of the ordinary brass furnace, but differing from usual practice, in England at least, in that they are not wind furnaces, but are fed with blast, from a small fan (about 20 in. diam.), driven by a strap from the engine of the "*marbrerie;*" the fuel is coke, and the advantages seem to be patent of this arrangement. The metal is "brought down," *i. e.* melted, very much faster, the "heats" can be repeated much more rapidly, and the consumption of coke is greatly less than with wind furnaces. Then again, when the crucibles are about to be "drawn," the blast is thrown off, and there is much less flare and heat to be endured by the man who lifts them out. The tops of these furnaces are of cast-iron, the covers of iron-bound square fire-tiles, and the tops are about 22 in. above the floor level.

The large air-furnace is fed with dry wood fuel, and will melt upward of 1,000 kilometers.

In older times statues were always cast in a loam-mould, put together piece by piece in the excavated pit, and, as fitted in place and jointed up, the pit was rammed up round them. This was but a make-shift mode, and had several serious evils: the mould never could be dried with perfect uniformity; and even when dry, it stood so long in the pit while being got ready, that it imbibed moisture anew, and hence so many "mis-casts" of old. Under the heavy head of liquid bronze, too, the ramming-in of the pit sometimes proved soft and deceptive, so that here or there the walls of the mould partially bulged, and the casting was either lost or damaged.

All M. Barbadienne's statues or large objects are cast therefore in cast-iron flasks or boxes, so that the pit is what iron-founders call a "naked pit," *i. e.* no ramming-up is practiced.

A "pool" or reservoir of sand with charcoal facing, is employed for all large castings, into which the contents of the crucibles are "teemed," or into which the air-furnace is tapped. When the full quantity of metal is in the pool, an iron conical plug, which had been inserted into and stopped the main "gait" or "*coulée*," is drawn up, and the metal enters the mould.

It passes off (as overplus) by "rising heads," as in cast-iron moulding, and "the gas is fired" at these, by a lighted torch in the same way. From the low temperature of the liquid bronze, however, as compared with cast-iron, but a small volume of gas is evolved from either moulds or cores.

The head of surplus pressure employed is always very small, for fear of distortion; a practice exactly the reverse of that of bronze-gun founding, where the "*masselet*" or "rising head" is often nearly as long as the gun itself above its muzzle, which is uppermost in the mould. It may be very much doubted, or even on plausible grounds contested, whether any advantage is obtained by these very long "gun heads," and whether some positive evils in the increased segregation of the alloy be not thus introduced. Bronze-gun founding, however, is now, in these days of huge wrought-iron artillery, somewhat an art of the past, it may be said. We must remember, however, that Prussia is returning to bronze rifled field-guns, and that our new rifled Indian artillery is also to be of bronze.

The metals employed by M. Barbedienne for his bronze are very pure "tile pitch" copper, and English or Straits tin, also of best quality. The copper is usually South American, again melted in France, purified by "liquation," and run into small pigs of about the size and form of ours known as "Best selected copper."

A proportion of bronze from "gaits and runners" is usually added, but the composition of this is *quam prox.* already known and constant, and its material is unadulterated, so no mischief can arise. No *old material*, whether copper, bronze or brass is ever employed; and the *directeur du travail*, who so intelligently and politely showed us round the works, and explained their methods with the lucid brevity so characteristic of the higher *contre-maître* of France, expressed his opinion that it was impossible ever to cast a first-rate statue or relief, especially of large size, from old bronze guns, or other old material of variable composition. He instanced many proofs of this; and, undoubtedly, the porous bad castings of the reliefs of the Napoleon Column in the Place Vendôme, of the statue of Desaix, etc., at Paris, and of our own Trafalgar Square lions seem to sustain this view.

That bronze ornamentation is not more widely diffused in Europe generally, and that it is so prevalent in France, arises from two main causes. Fiscal or custom-house regulation of absurd severity in the case of all the European nations; and on the part of the United States, and as respects ourselves, want of diffused good taste or perception of beauty in form, either in the interior or exterior of our public or our private buildings or national monuments.

For 100 kilos. of bronze, on entering the frontiers of each of the following nations, the duties are thus:

	Bronze.	Bronze gilded.
Russia	377 francs	470 francs.
Austria	250 "	250 "
Spain	155 "	155 "
France	20 "	100 "
Italy	17.17 "	100 "
Switzerland	16 "	100 "
Prussia	13.10 "	112.50 "

In United States 350 francs on 1,000 francs value.

Belgium	100	"	"	"	"
Holland	50	"	"	"	"

England and Portugal alone admit bronzes free.

The *bizarrerie* of these figures forms a curious commentary on the wisdom of finance ministers everywhere.

We must, however, reserve to a future article some further remarks upon these works for bronze, and upon ornamental zinc and iron castings, which follow humbly in its steps.

SEA-GOING TURRET-SHIPS.

From "The Practical Mechanic's Journal."

The completion, at Chatham, of the Monarch affords a fitting opportunity for a few remarks on sea-going turret-ships. It is well known that the earlier turret-ships of our navy—the Royal Sovereign and Prince Albert—are really coast-defense ships, since they have only a minimum of sail-power, and are so badly supplied with coal as to limit very narrowly their steaming capability; for coast and harbor defense they will, however, prove useful, should their services ever be required. Besides these, we have in our navy the far-famed Scorpion and Wivern, built by Messrs. Laird during the American war, and purchased by the Government after they had been for some time in the custody of the authorities on suspicion of being intended for the Confederates. Perhaps no vessels have ever attained a reputation more disproportionate to their real powers of offense and defense than these two ships; for, although thinly armored and but weakly armed, they have been frequently described as most formidable vessels. We do not, however, propose to discuss the merits or demerits of those ships, but simply to add respecting them that, although intended to keep the sea, and therefore provided with a moderate amount of sail, they have proved very inferior sea-boats, the Wivern having particularly distinguished herself by excessive rolling. The advocates of the turret system have always argued that the bad performance of these ships was in a great measure the result of their moderate size (they being of less than 1,900 tons burden), and have urged the desirability of bringing the turret system into competition with the broadside system in ships which, in point of size, could compare with our armored frigates; this trial will be rendered possible very shortly, when the Captain and Monarch are complete for sea. It would, of course, be folly to predict exactly what results will be obtained; one thing, however, seems certain, viz: that, as sea-boats, both of these vessels will prove far superior to any existing turret-ships; and there is every probability that the Monarch, if not the Captain also, will prove as efficient under sail as our broadside iron-clads.

Although classed together as sea-going turret-ships, there are some very great differences between the Captain and the Monarch. The former, we need hardly say, is supposed to be the fullest expression of Captain Coles' ideas respecting ships of the class; the latter was designed in the Controller's Department at the Admiralty, and must, therefore, be regarded as the representative ship of the type of which the naval officers, then at the head of our navy, most approved, and which the professional officers did their best to perfect. Looked at by an unprofessional spectator, the Monarch presents no special feature; she has the lofty sides and upper deck of a broadside ship, and is rigged in the usual manner. In fact, in all respects except the turrets, and some special arrangements of flying or hurricane deck for carrying boats, consequent upon the turret armament, the Monarch closely resembles the broadside ships which immediately preceded her. What would be the central battery on the main deck—if she were a broadside ship—is the space in which the turret-beds are built; and there are, of course, no port-holes in the side armor. On this central space or battery the armor rises to the height of the upper deck, about 14 ft. above the water; before and abaft it there is an armor belt, extending throughout the length, and reaching from about 5 ft. below the water-line up to a nearly equal distance above it. Instead of this, the Captain has her upper deck only 8 ft. above water, and throughout the length the armor reaches from a few inches below this deck down to about 5 ft. below water. She has a poop and forecastle above the upper deck, and a flying deck extends along the length between, this light deck being comparatively narrow, and being intended, unlike that of the Monarch, for working the sails. The Captain has tripod masts. Her turrets pass down through the upper deck, and the beds are built upon the deck below; the guns are, therefore, only about 9 or 10 ft. above water, while in the Monarch they are 15 or 16 feet. This is, doubtless an advantage of considerable importance in a ship like the Monarch, intended to fight in a seaway, since she could use her turret-guns when the Captain would be powerless; but this advantage has been purchased at a considerable cost. First of all, the Monarch is 800 tons burden more than the Captain, although she only carries about the same weight of turrets and guns as the Captain, and has armor of the same thickness; the different disposition of the armor in the Monarch requiring a much greater weight of armor than the Captain's system would require, and the lofty sides, of course, adding to the weight of hull. Then the Monarch, being a larger ship, has a greater weight of equipment, heavier and more powerful engines, and a greater weight of coal than the Captain, all of which, of course, must be regarded as the result of the difference of types. The side armor of the ships is nearly all 7-in.; the Captain has a little 8-in. in wake of the turrets. On the turrets the armor is 8-in. and 10-in., the greater thickness being used near the ports. The turrets, of which there are two in each ship, will each carry two 25-ton guns, throwing 600-lbs. shot. Besides these the Monarch has three $6\frac{1}{2}$-ton guns, two of which are in an armored bow-battery, and the third in an armored stern-battery; the Captain has two $6\frac{1}{2}$-ton guns, carried unprotected on the poop and forecastle.

In conclusion, we would remark that the turret system is at a great disadvantage when applied in a full-rigged sea-going ship like the Monarch or the Captain. By means of poops, forecastles, stays, shrouds, tripods, or other obstructions, it becomes impossible to fire the turret guns in very many directions, and hence the chief merit of the turret system—an all-round or nearly all-round fire—is forfeited. Direct fire, either ahead or astern, both of which are most important, is entirely out of the power of the turret guns of both ships; the Monarch, by means of the bow and stern batteries, making up for this failure to some extent, while the Captain is the most unsatisfactory of our recent ships, in so far as what are termed "arcs of impunity" are concerned. In fact, no greater contrast between ships can exist than that between the Captain, which has no power of firing within, say, 15° of the line of keel either ahead or astern, from her turrets, and the broadside ships of the Invincible class, which, from armored batteries amidships, can command an all-round fire. In this most important respect the broadside-ships have completely outstripped the turret-ships.

CHURCH'S EQUILIBRIUM SLIDE VALVE.

From "Engineering."

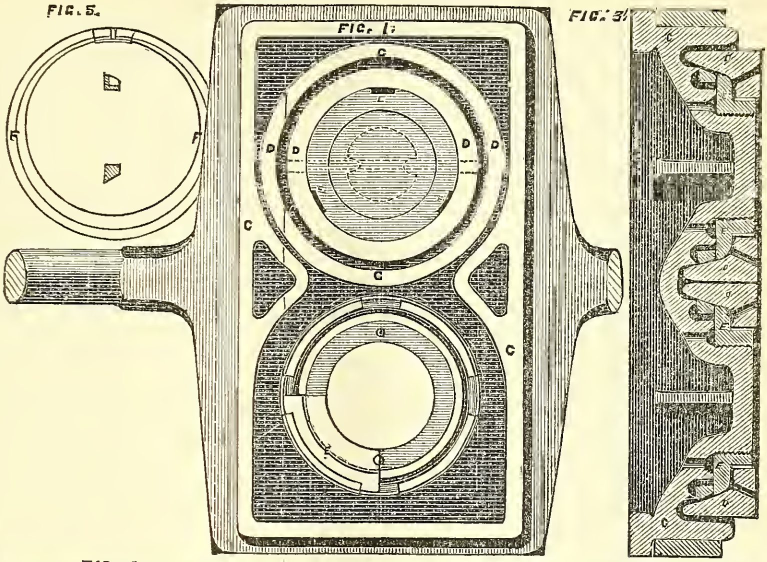


FIG. 2.

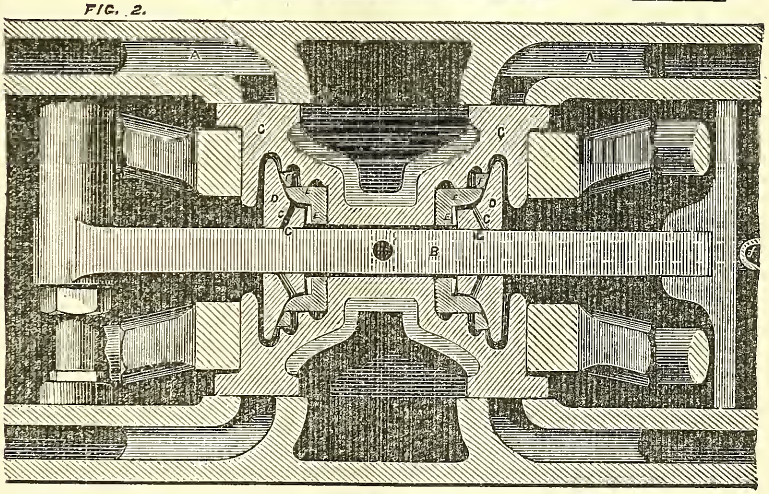
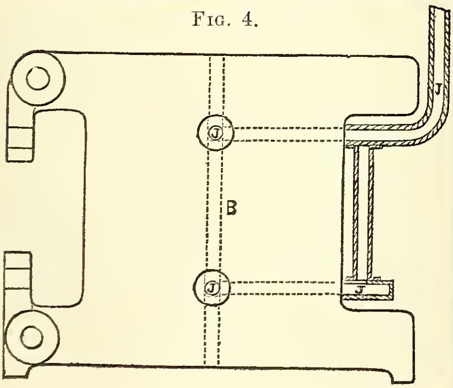


Fig. 4.



In the course of our account of the Conversazione recently held at the Institution of Civil Engineers, we mentioned a pair of equilibrium slide-valves, designed by Mr. W. C. Church, and which were exhibited on that occasion. In fulfillment of a promise then made, we now publish engravings of Mr. Church's arrangement, which will explain it fully. The particular pair of valves shown, on the occasion above referred to, had been taken for exhibition from a locomotive on the Great Northern Railway, on which line they had run up to the time of their removal 740 miles; and this trial, although not a long one, gave very promising results. The valves have, we believe, since been replaced in the engine to which they belong, in order that they may undergo a more extensive trial, and that the saving of fuel, which is obtained by their use, may be accurately ascertained; and we hope in due time to lay the full particulars of this trial before our readers. In the meantime we may remark that Mr. Church's equilibrium slide-valves, although at first sight apparently rather complicated, are in reality of simple construction. There are but few parts about them, and the pieces are all of such forms that they can be finished in a lathe, scarcely any hand labor being required to fit them together. The whole of the details, moreover, bear evidence of having been carefully considered, as the description of the arrangements which we shall now proceed to give will show.

Referring to our engravings, fig. 1 is a back elevation of one of the slide-valves we have mentioned, this valve being constructed for two caps or rings, D D, of which the object will be explained presently. In the figure one cap is shown in its proper position, and the other removed, showing a quarter of the junk ring. Fig. 2 is a vertical section through the steam chest, and fig. 3 is a section at right angles to fig. 2. Fig. 4 represents, detached, the division plate, with the pipes for carrying off any leakage of steam between the backs of the valves and the insides of the caps. Fig. 5 represents the metallic packing-ring detached. In these figures, A A are the steam-ports, B the division-plate, C C the slide-valves, D D the caps or rings applied to the back of the slide-valves, E E the junk rings, F F the metallic packing rings for keeping the caps, D D, steam tight.

In considering the action of Mr. Church's valves, it must be understood that the object of the caps is to prevent the steam in the steam-chest from acting on those parts of the back of the valve which are enclosed within the caps, or, more strictly speaking, those areas which are represented as enclosed by the lines of contact between the caps, D D, and the metallic packing rings, F F. It will be seen from the section of the cap (figs. 2 and 3), that the latter is of a conical form, both internally and externally, the object of this form, internally, being to enable the metallic packing ring, F, to act as an expanding ring, in order to press the cap up to the division-plate, B, when the steam is shut off from the steam-chest. The circular grove, G, and the holes, G^1, in each cap, D, and the holes, E^1, in the junk ring, E (seen best in fig. 1), are intended to carry off all steam that may leak between the surface of the cap, D, and the division-plate, B (or second valve, as the case may be), at a part of the cap that will prevent the occurrence of a pressure to remove the cap, D, from off its bearing face.

It will be seen that when the steam is in the steam-chest, the cap, D, is pressed up against its bearing face by the steam acting on an annular area, the width of which is equal to the difference in diameter between the metallic packing ring, F, and the cap, D. The caps, D D, are free to move on a fixed center, at a point, H, so as to compensate for unequal wear of the valves or the cap face, or for one side of the valve to lift in case of the engine priming. This is a feature in Mr. Church's arrangement which is worthy of special notice. The metallic packing ring, F, is also arranged in such a manner as to be capable of accommodating itself to the varying position either of the cap or valve. The said ring is so arranged that the steam presses it both outwards against the cap, D, and upwards against the junk ring, E.

The metallic packing ring, F, is also made conical on its outer circumference, for two reasons: first, in order to reduce the area of superficial contact between itself and the cap, D, and, secondly, in order to give the steam a larger area to act upon at the bottom of the ring; so that no amount of leakage on the top of the latter shall be able to place it in equilibrium, and thus destroy its required action. The holes, passages, and pipes, J and J^1, in connection with the division-plate, B, are intended for carrying off any steam that may accumulate in the cap, D. The pipes, J^1, are in communication with the atmosphere, and are furnished with cocks, so that in the event of any accident occurring to the caps, D D, these cocks can be closed; the effect of which will be merely to alter the action or condition of working of the valves, and reduce them to valves of the old construction, a great practical convenience.

The division-plate, B, is adjusted in position as required at the back end of the steam-chest, by means of set screws, as shown in fig. 2, and at the front end by means of two brackets fixed to the steam-chest lid, so that when the steam-chest lid is removed, the valves can be withdrawn in the usual way without disturbing the division-plate. Another mode of fixing the division-plate is to slide it into a groove provided for it in the top and bottom of the steam-chest. We should also mention that in one arrangement of his valves, Mr. Church employs no division-plate at all, but lets one valve work on the back of the other, and he at the same time arranges the steam ports so that the passages leading to the cylinders are much shortened. The adoption of this plan, which possesses several good points, of which we may speak more fully on another occasion, of course renders special cylinders necessary.

Mr. Church gives the following rule as that which he employs to determine the area of the cap or caps to be applied to the back of the valves.

"That portion of a slide-valve which does not leave the face of the ports at the end of the stroke, less the area of the steam ports, represents the area on the back of the valve, upon which there is a constant pressure, varying only with the pressure of steam in the boiler. And as it is the object of these improvements to remove this pressure, it becomes desirable to point out the following rule for determining the area of the back of any slide-valve, from which the said pressure may be removed, by the application of a cap or caps, as hereinbefore described. Let A equal the area of that part of the valve that leaves the face at the end of the stroke; C the total area of the steam ports; D the area of the annular cap or caps, for removing the pressure from the back of the valve. Then the formula will stand as follows:

$$A - (B + C) = D.$$

"To take an example—Let a slide-valve be supposed measuring $11\frac{1}{4}$ in. by 19 in. The total area of the back of this valve would be equal to 213.75 sq. in. The area of that part of the valve which leaves the port faces at the end of the stroke may be taken in this case as equal to 43.75 sq. in. The total area of the two steam ports is equal to 49.50 sq. in. Then 213.75—(43.-75 + 49.50) = 120.50 sq. in.; which shows the area of the cap or caps to be applied to the backs of the valves, or, more strictly, the area to be contained within the circle described by the line of contact between the cap or caps and the elastic metallic packing ring."

WHO INVENTED THE STEAMBOAT?

From the "American Artisan."

The question of who invented the steamboat could be correctly answered only by enumerating several projectors whose efforts succeeded each other during a period of three-fourths of a century. The propulsion of boats by paddle-wheels is said, indeed, to date back to the time of the Romans, but precisely in what way they applied the power is not known. As long ago as 1682, Prince Rupert, the courtly mechanician of the heyday of the Stuarts, propelled his barge in this way. In 1726, one Dr. Allen printed a pamphlet in London, in which he proposed to urge a vessel forward by a jet of air or water ejected from a pipe at the stern. He thought that by using steam power he could make three miles an hour in this way. In 1737, Jonathan Hulls published his invention, which may be considered the archetype of the modern steamboat. It had a paddle-wheel arranged at the stern, and worked by a steam-engine; but instead of the crank, the application of which to the steam-engine had not then been invented, Hulls employed a complicated set of devices for giving motion to the wheel. After this there was little or nothing suggested in the line of steam propulsion until 1782, when the Marquis de Jeoffroy tried a steamer on the river Loire in France. Instead of a paddle-wheel, he had the paddles arranged upon an endless belt that traversed two supporting pulleys, but the apparatus was not successful. Two years later, James Rumsey commenced experiments with a boat 80 ft. long, in which an engine worked a vertical pump that drew in water at the bow and ejected it at the stern. The reaction of the effluent water moved the vessel along at the rate of four miles an hour. This seems to have been a revival in some sort of Allen's plan; and substantially the same system has been frequently re-invented since, a recent and notable example of these jet-propellers being found in the English vessel, the Water Witch. In 1786, John Fitch made public his project of moving vessels against wind and tide by fitting them with vibratory paddles worked by steam-power. There were twelve paddles, six on each side of the boat, one-half of these on either side working alternately with the other half of the number. The paddles were designed to have a stroke of $5\frac{1}{2}$ ft., but it does not appear that the plan was ever subjected to actual trial. Fitch, however, did not rest content with this plan, else he would never have been heard of afterward, but was also the inventor of the screw-propeller, and also of the combination in one vessel of the screw and side-wheels—the principle of propulsion adopted in the Great Eastern. This screw-propeller, and mode of using it in connection with paddle-wheels, was shown by experiment, in 1796 or 1797, on the collect Pond, a sheet of water that in those days rippled where the grim Egyptian pile, the New York City "Tombs," now stands. The vessel is described as a common long-boat, 18 ft. long and 6 ft. wide, and steered at the bow. The steam-boiler was constituted by a twelve-gallon iron pot, with a lid made of a piece of plank firmly fastened down. The engine had two wooden cylinders, and the mechanical appliances for working the screw and paddle-wheels, although rude, were arranged with such effect that a speed of six miles an hour is said to have been obtained. The inventor, however, was too poor to continue his experiments, and too impatient of argument and contradiction to interest incredulous moneyed men of the day in his enterprise. The boat, with a part of its machinery, was drawn up and left on the shore of the pond, and piece by piece this type of the future steam-vessel fell to decay, and the children of the neighborhood gathered up its fragments and carried them home for kindling-wood. A few years later, Fitch, a broken and embittered old man, with feeble health and ruined fortunes, poisoned himself with opium, and was buried in Bardstown, Ky. To this day no monument or head-stone marks his resting-place, but the fulfillment of his prophecies is shown wherever the steam-whistle sounds over the placid waters of rivers or the turbulent foaming of the sea.

While Fitch and Rumsey were thus experimenting with steam propulsion, others were making trials in the same direction, with more or less success. As an illustration of the blunders that even truly great men will sometimes make, it may be noted that about the year 1786, Dr. Franklin proposed to propel vessels by the direct action of steam upon the water, which was, of course, found to be utterly out of the question. About the same time, Oliver Evans advocated the employment of paddle-wheels, and a boat was run for a short time between Philadelphia and Bordentown, but no details of its means of propulsion have been handed down. In 1787, Mr. Patrick Miller, of Dalswinton, in Scotland, made a double vessel, moved by a paddle-wheel at the stern, and two years after constructed another, 60 ft. long, that went at the rate of seven miles an hour, but proved too weak to bear the action of the machinery. It is said that these experiments cost Miller upwards of $150,000, for which he received no return whatever. A dozen years afterwards, William Symington, who had made the steam-engines for Miller's boats, induced Lord Dundas to build a steam-vessel for towing craft on the Forth and Clyde canal. This, the Charlotte Dundas, dragged along two sloops of 70 tons burden each against a strong head wind at a speed of 3½ miles an hour. The owners of the canal, however, refused to use this means of towing, because of the liability of injuring the banks by the undulations of the water—the principal reason to this day why steam has not been applied in canal propulsion. From this time forward steam navigation began to assume a more promising aspect and more tangible shape. In 1804, John Stevens, of Hoboken, N. J., had a boat 24 ft. long, fitted with a paddle-wheel at the stern, which, for short distances, made eight miles an hour. The greatest benefit, however, conferred by Stevens upon the engineering world was in the invention of the tubular boiler—a principle of construction that has worked wonders in steam-generators for all purposes.

We now come to the efforts of Robert Fulton, a man who possessed business talent, and the faculty of mastering the details of whatever he undertook, in a no less degree than inventive skill. He left Philadelphia in 1786, and went to London, where, as early as 1793, he communicated with Earl Stanhope concerning steamboats—this nobleman being something of an enthusiast on the subject, and having a plan of his own, which has come to be known as that of the duck's-foot propeller. This was simply a kind of folding oar, which opened to act against the water when pushed outward, and closed when drawn back at the end of the stroke. After this Fulton went to France, where he brought before Napoleon a method for blowing up the English ships; but although he made an apparatus by which he was enabled to remain under water for a period of 4½ hours, he did not destroy a single vessel of the enemy. His journey to France, however, did him some good, for it was there that he became acquainted with Chancellor Livingston, who furnished the funds by which he was finally enabled to put his plans for steam propulsion into practice. Assisted by Livingston, he, in 1803, made experiments on the river Seine with a paddle-wheel boat 60 ft. long. The results were so favorable that it was concluded to attempt, without delay, the introduction of steam navigation on American waters. An engine was ordered from the English workshops of Boulton & Watt, and was duly forwarded to New York. In 1807, the Clermont was launched on the East River, and at once commenced running on the Hudson, between New York and Albany. Since then, until the present hour, there has not been a single day when vessels have not been propelled against wind and tide by the power of steam—the Clermont having been, if not the earliest practical steamboat, at least the first steam-vessel to establish a system of regular trips between different places.

METROPOLITAN RAILWAY ROLLING STOCK.

From "Engineering."

A few weeks ago there appeared in a contemporary* an article on the rolling stock now in use on the Metropolitan Railway, this article containing what was professedly a comparison of the stock belonging to the Metropolitan Railway Company proper with that employed by other companies running trains over the Metropolitan line. The deductions drawn from this comparison were so startling, and in some respects so at variance with our own ideas on the subject, that we determined to investigate the matter further, and the result has been that we have, as we anticipated, discovered in our contemporary's article many grave mis-statements of facts which, in common fairness to those by whom the Metropolitan rolling stock was designed, deserve to be exposed. And here we may remark that although, in the instance we have referred to, we consider that the rolling stock of the Metropolitan line has been most unjustly criticized, yet we are by no means desirous of having it supposed that we consider the stock, as a whole, perfection. With the engines we consider that little or no fault can justly be found. They are in all respects thoroughly well adapted to the exceptional work they have to perform; their construction is such that their working expenses are very moderate; and, as we shall show presently, their weight is in no way excessive when all the circumstances of the case are taken into consideration.

With the carriages the case is somewhat different. Their weight (16 tons each empty) is no doubt too great even when the excellent accommodation they afford is taken into consideration; but in speaking of this weight it must be remembered that it was incurred under exceptionable circumstances. Before the Metropolitan line was opened were many who affirmed—and apparently with a certain amount of reason—that it would never be a success. It was asserted that the public would never "take" to an underground line; that they would object to travel to and fro, shut out from the light of day; that it would be found impossible to keep the tunnel properly ventilated, and that, in fact, the whole affair was a mistake. How, as a matter of fact, the public *have* "taken" to the line and used it as no line was ever used before, is well known; but it is not known, and never can be known, to how great an extent this has been due to the excellence of the accommodation which Mr. Fowler's judgment led him to provide. In station appointments and passenger accommodation generally the Metropolitan line set an example to the whole of the railways in the kingdom; and the example has, we are glad to say, been appreciated and followed. At the time the Metropolitan line was opened, the carriages employed by all our leading railway companies for metropolitan or local traffic were practically identical with those used on trains running long distances. Yet in the former case, where people are continually entering and leaving the carriages, there is a greater necessity for ample height and space between the seats, and Mr. Fowler, therefore, had constructed for the Metropolitan line—where the stoppages occurred at exceedingly short intervals—carriages with far greater head-room, and, indeed, more spacious generally than any running at that date. It was on the Metropolitan Railway, also, that the public were first indulged with the luxury of thoroughly well-lighted carriages; and it was in fact on this line that the problem of lighting railway carriages by gas was first successfully worked out on anything like an extensive scale. Of course the extra accommodation and the addition of the gas-holders, etc., all involved additional weight

* See V. N.'s Magazine, July page 589.

in the rolling stock; and it is, we think, not to be wondered at that in first designing carriages involving many novel points of construction, this additional weight should have been allowed to become somewhat greater than it need have been.

Leaving generalities however, let us state briefly the accusations against Mr. Fowler's rolling stock contained in the article to which we have referred. As regards the engines, it is affirmed that the driving wheels (the diameter of which is wrongly stated as 5 ft. 6 in. instead of 5 ft. 9 in.) are inexcusably large, and that these large wheels led to the adoption, as a necessity, of large cylinders; our contemporary adding: "We need not stop to explain how great an augmentation of weight this entailed." Further, it is stated that, "It was next assumed that the curves would be bad to get round with a six-wheeled engine, therefore a bogie was introduced principally because the engine was made too long to begin with. This further increased the weight, and so, finally, Mr. Fowler produced the now well-known narrow gauge standard Metropolitan engine, weighing nominally 42 tons, but in all probability at least 45 tons loaded. This monstrous machine is employed to haul trains consisting of five not less monstrous carriages . . . The driving wheels are much too large, the machine too long, and, above and beyond all, the enormous weight of the machine constitutes a grievous defect." Our contemporary then goes on to say that although it has apparently brought grave accusations against Mr. Fowler, yet that these accusations have been made much more forcibly by "no fewer than three of the largest and most powerful railway companies in the kingdom," these being stated to be the Great Northern, the Midland, and the Great Western companies. Moreover, a detailed comparison is made between the Metropolitan and Great Western rolling stock; but this comparison we shall leave for the present, and shall in the first place consider the statements concerning the Metropolitan engines, which we have reprinted above.

To begin with, then, let us consider the assertion—urged so strongly by our contemporary—that the wheels of Mr. Fowler's engines are "much too large." Now of course we cannot say precisely what particular dimension "much" may denote, but judging from the praise bestowed (and much of it most deservedly) on the new Great Western engines, we are inclined to believe that, in this particular instance, the term stands for 9 in., the driving wheels of the new Great Western engines being 5 ft., and those of the Metropolitan engines 5 ft. 9 in. in diameter. It would be foreign to the purpose of the present article to enter into all the arguments that have been advanced for and against large driving wheels, and we shall therefore merely refer to the two principal ones, these being, first, that the larger the driving wheels the less will of course be the number of revolutions made in running a given distance, and the greater, therefore, will be the durability of the tyres and of the wearing surfaces of the "motion" generally; and, secondly, on the other hand, that the larger the driving wheels the greater will be their weight, and the greater also will be the size and weight of the cylinders, pistons, and their connexions, requisite for giving a certain tractive power. Our contemporary, whose remarks we are criticizing, has stated that the "much" too large wheels and cylinders of Mr. Fowler's engines have led to a "great augmentation of weight," but it has deemed it unnecessary to explain how this "great augmentation" is caused. As a fact, the two pairs of coupled wheels of the Metropolitan engines if decreased from 5 ft. 9 in. to 5 ft. in diameter, would be reduced in weight but about 13 cwt.; while the corresponding reduction which might at the same time be made in the size of the cylinders (the tractive power of the engine being maintained the same as at present) would amount to about $1\frac{1}{2}$ cwt., making the "great" total of $14\frac{1}{2}$ cwt. as the saving under these two heads. Of course with the smaller cylinders some reduction might be made in the weight of the pistons, piston rods, connecting and coupling rods, etc.; but this would not amount to much if the bearing surfaces were maintained of such dimensions as to give the same durability as is obtained with the larger wheels. The question then arises whether these little savings in weight would compensate for the more rapid wear of tyres, etc., due to the reduced size of driving wheel; and the only way in which we can answer this question is by referring to the proportions which the locomotive practice of the last few years has shown to be best suited for engines working traffic similar to that on the Metropolitan Railway. In the first place we find that Mr. William Adams, of the North London Line (an engineer who has probably had more experience in working what may be called "omnibus" traffic than any locomotive superintendent in the kingdom), although he has lately built some engines with 5 ft. 3 in. coupled wheels, has for many years past employed, as his standard locomotives, engines having coupled wheels and cylinders of precisely the same dimensions as Mr. Fowler's; while the Great Northern, the Great Eastern, the London, Chatham, and Dover, and the South-Eastern lines are employing locomotives with 5 ft. 6 in. coupled wheels for their local traffc. A reference to the best practice therefore shows that as regards the size of their driving wheels, there is nothing unusual in the Metropolitan engines, and that there is no foundation for the assertion of our contemporary that these engines have wheels "much too large;" while, moreover, the Midland Company (who are expressly cited by our contemporary in support of its arguments) are running their "metropolitan" trains with engines having driving wheels no less than 6 ft. 2 in. in diameter.

Next, it is stated in our contemporary, that the Metropolitan engines were made too long, and that it was then endeavoured to compensate for this by fitting them with a bogie. If the writer of the article in question had ever designed a locomotive, he would probably never have made so silly an assertion. The fact was, that Mr. Fowler considered—and with good reason—that a locomotive with a flexible wheel-base was best suited for working a line with numerous curves like the Metropolitan, and he, therefore, adopted bogie engines, the result, of course, being that the total wheel-base was rendered longer than it otherwise would have been. In this adoption of a long and flexible wheel-base, Mr. Fowler is also supported by the practice on most of our principal lines, as the following Table, giving the wheel-bases, etc., of engines employed in working metropolitan traffic, will show:

Name of line to which engines belong.	Total wheel-base.	Length of rigid wheel-base.	Arrangement adopted for giving flexibility.
North London	22 2	8 0	W. Adams' bogie.
" "	20 8	8 0	" "
Great Northern	19 3	7 6	W. B. Adams' radial axle-boxes.
South-Eastern	20 6	7 3	W. Adams' bogie.
Metropolitan	20 9	8 10	Bissell's bogie.

The new "Metropolitan" engines of the Great Western Company and those of the Midland Company have certainly rigid wheel bases, the former being 15 ft. 3 in., and the latter no less than 16 ft. 6 in.; but we have yet to learn how the flange wear of the tyres of these locomotives will compare with that of the bogie engines used by other companies; while we must remember that increased flange wear means also increased wear and tear of the permanent way. As for the increased weight due to the adoption of the four-wheeled Bissell bogie on the Metropolitan engines, it probably amounts, we believe, to about 3 tons 2 cwt.; but in return for this there is obtained not only the decreased wear of flanges and rails, but also increased safety. And here we may remark that the statement made by our contemporary, that on the Metropolitan Railway "the bad curves are few in number, and at the worst can do no great harm, because the speed at which they are traversed, as at King's-cross, for example, is low," is far from expressing the state of affairs correctly. All who have ridden over the Metropolitan Railway on an engine well know, or should know, that the line is essentially one with frequent curves; and, although none of these may be considered exceptionably sharp, according to the light in which such matters are now viewed, yet numbers of them are of but 10 chains radius, and are traversed at speeds of over 25 miles per hour.

We now come to the third principal objection made by our contemporary to Mr. Fowler's engines, namely, to their alleged "enormous weight," which it said exercises a most destructive action on the permanent way. Says our contemporary: "There is no denying the fact that the standard engines play havoc even with the permanent way of the Metropolitan Railway, smashing off the tables of steel rails, and grinding out the best Bessemer track, perhaps in the world, as though it were made of iron." Now, notwithstanding the assertions of our contemporary we most emphatically deny that the steel rails on the Metropolitan railway are being crushed or having their tables smashed off by the loads imposed upon them. We lately walked over a considerable length of the line and found no signs whatever of anything but fair and even wear taking place, except at stations where a certain amount of lamination of the rails is caused by the action of the brakes and by the occasional slipping of the engines when starting. There are now in the Metropolitan line, between King's-cross and Farringdon-street, Bessemer steel rails which were laid down in April and May, 1866, and which have consequently been on the road upwards of three years. During that time they have been traversed by the following numbers of trains:

Metropolitan	161,000
Great Western	39,000
London, Chatham, and Dover	10,000
Great Northern	17,000
	227,000

Even this vast number does not include empty engines passing to and from sheds, and which during the time we have mentioned would probably amount to not less than 15,000 or 20,000. Notwithstanding that they have carried this enormous traffic, the rails show nothing but an exceedingly slight and perfectly uniform wear, and there are no signs whatever of "smashing" due to excessive loads. At the stations the skidded carriage wheels do undoubtedly produce lamination, and it is curious on passing the finger—or still better, the point of a pin or penknife—over the rails to feel how the surface has, as it were, been rubbed down in the direction of the traffic. This, however, has nothing to do with the weight of the engines. Of this weight we shall have more to say when considering the comparison between the Metropolitan and Great Western locomotives; and in the meantime we shall merely remark that the correct weight in working order is 42 tons 3 cwt.—not "at least 45 tons," as stated by our contemporary; while the weight resting on the coupled wheels is 30 tons. These weights are practically the same as those of the standard engines used by Mr. William Adams on the North London line, while the Midland "metropolitan" locomotives, which are stated by our contemporary to be "a modification of Mr. Fowler's design, the engines weighing much less, however," are, in reality, engines with a rigid wheel-base of 15 ft. 6 in., having 16½ in. cylinders, with 22 in. stroke, 6 ft. 2 in. coupled wheels, and weighing, in working order, 43 tons 4 cwt., of which over 32 tons rest upon the coupled wheels.

We shall now consider the comparison made by our contemporary between the standard Metropolitan locomotives and those recently placed on the line by the Great Western Company for working their metropolitan traffic; and in the first place it may be as well that we should give a few particulars of the latter engines, and the work done by them. The new Great Western locomotives, then, have inside cylinders 16 in. in diameter, with 24 in. stroke, and they are carried on six wheels, the driving and trailing wheels, which are 5 ft. in diameter, being coupled, and there being a single pair of leading wheels in front. The wheel base is 15 ft. 3 in., and their weight in working order is a little over 33 tons, of which about 23 tons rest on the coupled wheels. And here, before proceeding further, we may remark that in carrying out our comparison between the Metropolitan and Great Western engines, we are very far from wishing to find fault with the latter. They are of thoroughly good and remarkably neat design, and we believe them to be well adapted for the work which they have to perform; but this work is not the same as that which is required of the Metropolitan engines, and it is in neglecting to note this fact that our contemporary has so greatly erred. The regular load drawn by the Great Western engines over the Metropolitan line between Bishop's-road and Moorgate-street, consists usually of six or sometimes seven carriages, two of these carriages carrying each 40 passengers, including the guard and brakesman, and the remaining carriages accommodating each 32 passengers. The six-carriage trains have thus seat room for 202, and the seven-carriage trains for 240 passengers. Regarding the weight of these carriages we have no precise information; but they are of light construction, and we should think that they probably weigh about 6½ tons each, or about .2 ton per passenger carried. Of the total distance run by the Great Western engines, about five-ninths is run on the Metropolitan line, and the remainder on the Great Western line, where no condensation of the exhaust steam is required. This fact should be taken into consideration in comparing the Great Western and Metropolitan locomotives. The usual load drawn by the latter engines, we should state, consists of a train of five carriages, accommodating 352 passengers, this train being made up as follows: One first class, holding 48 passengers; one composite, carrying 24 first class and 40 second class passengers; one second class, holding 80 passengers; and two third class, accommodating together 160 people. The carriages weigh 16 tons each, their weight being thus .312 ton per passenger for the first class; .25 ton per passenger for the composites; and .2 ton per passenger for the third class.

Arguing on these premises, our contemporary says: "We have, then, the Great Western Company doing the same work that the Metropolitan are doing, with a dead weight less by at least twenty-five tons per train, if we assume ten of the Great Western carriages, to carry only as many as five of the Metropolitan carriages." Now, as a fact, the ten Great Western carriages could not carry so many passengers as the five carriages forming the usual Metropolitan train, while the saving of weight would, we firmly believe, be under twenty-five tons rather than over it. The assertion that the Great Western Company are doing the same work as the Metropolitan Company with lighter engines and much less dead weight, we must decidedly deny. The maximum train worked by the Great Western Company over the Metropolitan line consists, as we have said, of seven carriages, and taking this as the standard of comparison with the Metropolitan five-carriage train, we find the relative dead weights to be as follows:

	Metropolitan.	G. W. R.
Weight of engine......	42 tons.	33 tons.
" train, about	80 "	about $45\frac{1}{2}$ "
Total of engine and train, about	122 "	about $78\frac{1}{2}$ "
Number of passengers carried............	352	240
Weight of engine per passenger	.119 ton	.137 ton
Weight of engine and per passenger about.	.346 ton about	.327 ton

We thus see that the weight of the engine per passenger drawn is actually less in the case of the Metropolitan than in the Great Western trains, while the total dead weight per passenger is nearly the same in the two cases. It may be said, and no doubt truly, that the Great Western engines are underwork; but the same is equally true of the Metropolitan locomotives; and, in fact, the latter have been designed for working not merely the present traffic, but the traffic which it is expected will be obtained when the whole line is completed. In fact, the short stations on the line are now being lengthened, to allow of longer trains being worked. Moreover, in comparing the performance of the two sets of engines, it must be borne in mind that while the Great Western trains traverse but $4\frac{1}{2}$ miles of underground line, the Metropolitan trains are worked from Moorgate-street to Westminster, a distance of $9\frac{1}{2}$ miles, and the Metropolitan engines thus require and carry 1,000 gallons of water for condensing purposes against 750 gallons carried by the Great Western engines. The maximum gradient also on that portion of the line traversed by the Great Western trains is 1 in 100, whereas between Praed-street and Westminster there are several gradients of 1 in 70. Thus, the work done by the Metropolitan is much heavier than that performed by the Great Western locomotives.

Taking all things into consideration, we cannot consider that the Metropolitan engines are too heavy for the duty demanded of them. They are certainly 9 tons (not 12 tons, as stated by our contemporary) heavier than the Great Western engines, but they have the advantage of a greater firegrate area, a greater firebox heating surface, a greater water capacity in the boiler (an important matter for engines working underground traffic) a greater adhesion weight, a greater tank capacity, and last, but not least, they have a flexible wheel-base, and are fitted with a compensating beam between the coupled wheels. As regards tractive power, the two sets of engines are practically identical, the tractive force exerted for each pound of effective pressure per square inch on the pistons being 100.5 lbs. in the case of the Metropolitan, and 102.4 lbs. in that of the Great Western locomotives. They would thus possess, as far as cylinder power is concerned, equal capabilities for starting a train; but on an underground line, where the exhaust cannot be discharged into the chimney, the additional firebox capacity and water space in the boiler would give the Metropolitan engines an undoubted advantage for maintaining speed.

Our article has already extended to a greater length than we intended, but we cannot conclude it without directing attention to a most extraordinary conclusion arrived at by our contemporary with regard to the facts we have been considering. It says: "If Mr. Fowler's method of working Metropolitan traffic can be made to pay—and it is—then much more should the Great Western system pay. *In the case of the engines alone, the cost of transmitting each ton of dead weight from place to place cannot be much less than 2d. per ton per mile.* Taking the very moderate estimate of 20,000 miles as the distance run each year by each engine, we have a saving of 12 tons less in the Great Western engines, as compared with the standard Metropolitan engines, of £166 per engine per annum, or for the Metropolitan Railway Company, with 36 engines, a saving of, in round numbers, £6,000 per annum!" The italics are our own, and we fancy that the passage we have italicized will astonish most railway men. As a fact, the locomotive and carriages expenses on the Metropolitan line average about 13d. per train per mile, and taking the mean gross weight of the trains as low as 130 tons, we find the mean cost of transport per ton per mile to be but .1d. instead of 2d. as stated by our contemporary. Extraordinary, however, as is our contemporary's statement that the cost of transport is not less than 2d. per ton per mile, the arithmetic by which this cost is made to show a saving of £166 per engine per annum is still more extraordinary. According to ordinary methods of calculation 12 tons carried 20,000 miles at 2d. per ton per mile would give £2,000 not £166! The real difference of weight of the engines, however, is 9 tons not 12 tons, and at .1d. per ton per mile this gives for 20,000 miles per annum, £75 per engine per annum, or £2,700 for the 36 engines, a sum which we think would be *hardly* compensated for by the decreased efficiency.

IRON AND STEEL NOTES.

Smelting, Carburizing, and Purifying Iron.—Mr. Isham Baggs, of High Holborn, has patented some processes by means of which the smelting, carburization, and purification of iron are greatly facilitated. In charging the furnace, the coal or coke usually thought necessary for smelting is in a great measure dispensed with, and in its place, Mr. Baggs burns in the smelting furnace coal gas, hydrogen, carbonic oxide, or other combustible gas or gases, and also the vapor of petroleum, naphtha, and other hydrocarbons under pressure and in combination with a blast of hot or cold air. In the case of the inflammable hydrocarbon vapors, the same may be forced into the furnace under the pressure of their own atmospheres, or by means of mechanical appliances. The gases and vapors which are employed for the purposes of this invention may be previously mixed with the air furnished by the blast, or may be caused to meet the air in the furnace or at the tuyeres. The proportions of the mixture when a combination of gas or vapor and air is employed are subject to constant regulation by valves. One very convenient mode of obtaining combustible gases for the purposes of this invention is to generate coal gas in the usual way, and then carbonic oxide, and to blow air or carbonic oxide gas under pressure through the retort containing the residual coke.

For the purpose of carburizing the iron, whether in or out of the furnace, as may be desirable, coal gas or other carbides, or other materials containing carbon, are blown through the furnace or brought into contact with the molten metal by blowing them through it. Carbon in any suitable form or combination may also be directly introduced into the furnace for the purpose of carburization, and although generally for smelting purposes it is desirable to exclude all solid mineral fuel from the furnace as part of the charge, yet where a suspension of operations is necessary, such a charge of coal, coke, or other fuel may be introduced into the furnace as will prevent the materials on renewal of work from falling through the crucible or any iron remaining therein or below it from being permanently solidified. When purification is required, hydrofluoric acid is blown through the molten metal on its way from the furnaces, the gases being mixed with common air or with some gaseous diluent.—*Mechanics' Magazine.*

Iron and Steel Institute.—On Wednesday evening, June 23d, at the rooms of the Society of Arts, the first meeting of the newly formed Iron and Steel Institute, which was very fully attended by ironmasters from the North, Lancashire, South Staffordshire, South Wales, Middlesborough, etc., was held under the presidency of his Grace the Duke of Devonshire, the President, who delivered a lengthy and exhaustive inaugural address. His Grace explained the objects of the institute, which are to afford a means of communication between members of the iron and steel trades upon matters bearing upon the respective manufactures, excluding all questions connected with wages and trade regulations, and to arrange periodical meetings for the purpose of discussing practical and scientific subjects bearing upon the manufacture and working of iron and steel. He reviewed the success which had attended the formation of scientific and agricultural societies, and saw no reason why equal advantages should not accrue to the iron trade by association. Then his Grace passed on to review the early history of iron, the manufacture of which was mentioned by Homer and Hesiod, and had been asserted by Mr. Layard to have been known in Assyria in 900 B. C. He then noticed the early methods of manufacture dowu to the period of the use of coal, which gave such a vast impetus to the manufacture of iron in this country, and afterwards referred to the invention of the "hot blast," the increased supplies of ore, and other causes which had contributed to the present importance of the iron manufacture. The processes by which pig iron, malleable iron and steel are manufactured having been alluded to, the president referred to the utilization of the waste of gases from the blast furnaces, and went on then to show how the raw material and manufacture were distributed over the world. The problems to be solved now, which were of the most importance, were economy in the consumption of fuel, and a greater ultilization of the waste gases. Mineral oil had been used in the dockyards in place of coal. It was also highly important to obtain the metal as pure as possible, and though chemistry had been brought to the aid of the manufacture, yet the chemistry of iron and steel was still in many respects obscure and uncertain. His Grace concluded by a brief bu teloquent reference to the importance of iron as an essential necessary of civilized life. Mr. Richard Fothergill, M. P., moved a vote of thanks to his Grace for his address, and requested that it should be printed. Mr. Isaac L. Bell seconded the resolution, which was carried by acclamation.—*Engineering.*

Metal Product of Russia.—In Russia, in 1867, there were 1,211 iron smelting works, employing 87,086 hands, and yielding products valued at $92,042,918. The value of the manufactures of other metals is thus stated:—Silver, $2,205,164; lead, $3,791,840; copper, $2,991,552; brass, $1,-608,271; zinc, in bars or plates, $6,385,993; other zinc, $2,104,254.

PARTICULARS OF BLAST FURNACES.

Prepared by Dr. Thomas Egleston, jr., Professor of Mineralogy and Metallurgy, Columbia College School of Mines.

NOTE.—The dimensions are in meters = 39.38 in.

American Furnaces (Charcoal).

NAME OF THE STATE.	Total height.	Height of bosh.	Height of hearth.	Height of tuyeres.	Diam. of throat.	Diam. of bosh.	Diam. at tuyere.	Volume of hearth.	Volume of etalages.	Volume of shaft.	Total volume.
Connecticut	7.315 to 10.055	3.048 to 5.18	1.52 to 1.828	.533 to .609	3.914 to 1.22	2.13 to 2.74	.609 to .710	.444 to .723	2.076 to 9.144	8.186 to 16.386	10.985 to 25.974
Indiana	8.534	3.048	1.828	.508	.914	3.048	.914	1.198	4.121	18.528	23.847
Kentucky	10.972	2.743	.914	....	.863	2.743					
Michigan	12.192 to 12.801	3.960	.456 to 1.828	.609 to 634	1.066 to 1.524	2.743 to 2.895	.939 to 1.117	.446 to 1.304	6.537 to 10.851	26.805 to 33.152	36.033 to 41.100
Missouri	12 192 to 13.716	1.524 to 3.149	1.778 to 1.828	.701	1.026 to 1.524	2.895 to 3.352	.713 to .914	.709 to 1.198	3.979 to 5.276	35.774 to 42.660	40.462 to 49 134
Maryland	8.229 to 10.363	1.244 to 2.631	.152 to 1.828	.508 to .584	.558 to .751	2.285 to 5.539	.558 to .762	.044 to .832	1.502 to 21.057	10.318 to 48.999	12.652 to 70
New York	9 75 to 13.106	2 895 to 3.656	1.524 to 1.980	.406 to .660	.50 to 1.219	2.438 to 3.352	.609 to 1.676	.583 to 1.298	3.623 to 4.257	33.537 to 41.338	38.377 to 46.259
Pennsylvania	8.534 to 10 058	2.438 to 3.048	1.371 to 1.524	.355 to .609	.406 to .812	2.590	.193 to .609	.039 to .427	1.384 to 2.564	10.524 to 16.057	11.948 to 18.478
South Carolina	12.192	1.524	1.219 to 1.524	....	.914	2.743	.584	.368	3.744	26.439	30.559
Tennessee	12.192	3.566	1.828	584	1.219	2.133	.761	.831	3.228	19.290	23.341
Virginia	10.058 to 12.192	4.226	1.828 to 2.438	....	.558 to .914	2.743	.609	.708	4.573	22.541	27.822

NAME OF THE STATE.	Production in 24 hours	No. of c. m. in furnace by ton iron produced.	No. tons iron by met. of bosh.	No. of tuyeres.	Diam. of tuyere.	Temp. of blast.	Pressure of blast.	Kind of ore.	Yield of the ore.	Kind of iron.	Quantity of fuel to ton of cast-iron.
									per cent.		
Connecticut	4.064 to 10.106	2.580 to. 2.878	1.9 to 3.6	1 to 4	.050 to .082	cold to hot	.315 to 2.268	Brown Hematite	40–45	White Gray Mottled	130-200 bushels
Indiana	7.112	3.353	2.3	1	.076	hot	....	Hematite	40	Soft gray	185 bush.
Kentucky	6.096	....	2.2	....	....	cold	....	Various pipe kidney	40–75	Gray	200 bush.
Michigan	14.224 to 16.256	2.500 to 2.533	5 to 5.5	2	.088 to .101	280° to 314°	.624 to .676	Hematite Magnetite Specular	59–65	Gray White Mottled	105–155 bushels
Missouri	15.240	2.906 to 3.221	4.5 to 4.7	2 to 3	.076 to .095	314°	1.132 to 1.585	Specular	54.65	Gray	133-160 bushels
Maryland	5.080 to 7.112	2.075 to 9.856	1.2 to 2.6	2	.063 to .288	314°	....	Baltimore ore and Hematite	40-45	Gray White Mottled	130–170 bushels
New York	5.080 to 10.160	5.443 to 6.295	2 to 3	1 to 6	.046 to .068	300° to 800°	.113 to .453	Hematite Magnetite	36-54	Gray White Mottled.	100–192.1 bushels
Pennsylvania	3.551 to 6 096	2.657 to 4.041	1.6 to 2.3	1 to 2	.063 to .228	cold to 148°	.339 to .907	Brown Hematite	33–40	Gray	150–220 bushels
South Carolina	2.032	15.034	.7	2	.076	cold	9k.	Magnetite Hematite	40-50	Gray Mottled White	350–400 bush.
Tennessee	5.080 to 7.112	3.830	2.8	1	.088 to .127	cold	....	Limonite	45–50	Gray Mottled	250 bush.
Virginia	3 048 to 6.096	4.563	.9 to 2.2	1	.076	cold	....	Red Hematite	50–80	Gray White	200 bush.

American Furnaces (coke and coal mixed).

NAME OF THE STATE.	Total height.	Height of bosh.	Height of hearth.	Height of tuyeres	Diam. of throat.	Diam. of bosh.	Diam. at tuyeres.	Volume of hearth.	Volume of etalages.	Volume of shaft.	Total volume.
Pennsylvania	13.715	2.895	1.524	1.971	1.828	3.960	1.752	3.670	9.215	69.862	82.747

American Furnaces (coke and coal mixed)—Continued.

Name of the State.	Production in 24 hours	No. of c. m. in furnace by ton iron produced.	No. tons iron by met. of bosh.	No. of tuyeres.	Diam of tuyere.	Temp. of blast.	Pressure of blast.	Kind of ore.	Yield of the ore.	Kind of iron.	Quantity of fuel to ton of cast-iron.
Pennsylvania ..	20.320 to 36.587	2.908	7.1	7	.076	314° to 370°	.793k.	Magnetite Specular	per cent. 50–65	all kinds	80 bushels.

American Furnaces (Bituminous Coal).

Name of the State.	Total height.	Height of bosh.	Height of hearth.	Height of tuyeres.	Diam. of throat.	Diam. of bosh.	Diam. at tuyeres.	Volume of hearth.	Volume of etalages.	Volume of shaft.	Total volume.
Ohio	12.801 to 18.288	4.112 to 5.186	.761 to 1.828	.914 to .964	.859 to 2.855	3.656 to 4.876	1.524 to 2.133	1.678 to 3.333	13.510 to 43.329	50.486 to 156.263	77.989 to 202.825
Pennsylvania	12.18 to 12.28	4.112 to 5.485	1.217 to 1.828	.609 to .659	1.524 to 2.439	3.540 to 3.960	1.825 to 1.980	5.627 to 10.320	16.402 to 21.413	58.651 to 89.189	74 to 111.218

Name of the State.	Production in 24 hours	No. of c. m. in furnace by ton iron produced.	No. tons iron by met. of bosh.	No. of tuyeres.	Diam. of tuyere.	Temp. of blast.	Pressure of blast.	Kind of ore.	Yield of the ore.	Kind of iron.	Quantity of fuel to ton of cast-iron.
Ohio	20.320 to 40.640	3.124 to 4.980	4.7 to 8.3	6 to 7	.088 to .127	425° to 536°	1.019 to 2.721	Black band Lake Superior	per cent 35–65	White Gray Mottled	k. 2500–4025
Pennsylvania ..	14.224 to 20.320	5 to 5.743	3.9 to 5.1	3 to 6	.063 to .076	314°	1.585 to 2.268	Lake Superior	35–36	Mottled	2258

American Furnaces (Anthracite).

Name of the State.	Total height.	Height of bosh.	Height of hearth.	Height of tuyeres.	Diam. of throat.	Diam. of bosh.	Diam. at tuyeres.	Volume of hearth.	Volume of etalages.	Volume of shaft.	Total volume.
New York........	12.801 to 18.29	3.048 to 7.315	1.676 to 2.133	.761	1.828 to 2.743	3.60 to 6.705	1.21 to 1.828	2.624	10.350	126.282	3.294 to 228.937
New Jersey	11.582 to 19.812	2.895	.711	....	1.219	2.895 to 6.096	1.372	1.050	8.095	30.279	39.442
Pennsylvania.	9.144 to 17.373	2.743 to 9.142	.609 to 2.439	....	1.066 to 3.658	2.3 to 6.705	.736 to 2.438	.599 to 5.625	4.012 to 50.666	24.619 to 134.539	29.278 to 234

Name of the State.	Production in 24 hours	No. of c. m. in furnace by ton iron produced.	No. tons iron by met. of bosh.	No. of tuyeres.	Diam. of tuyere.	Temp. of blast.	Pressure of blast.	Kind of ore.	Yield of the ore.	Kind of iron.	Quantity of fuel to ton of cast-iron.
New York.	14.228 to 37.593	4.402 to 8.658	2.9 to 8	2 to 6	.076 to .116	cold to 425°	1.132 to 2.721	Magnetite Limonite	per cent 40–68	Gray White. Mottled	2
New Jersey....	8.279 to 24.384	4.764	2.86 to 4	3 to 5	.046 to .101	259° to 303°	1.360 to 1.814	Magnetite Limonite	....	....	8.581k.
Pennsylvania ..	9.144 to 35.561	3.028 to 10.875	2 7 to 7.9	3 to 12	.036 to .177	148° to 481°	1.132 to 3.628	Magnetite Hematite	30–60	Gray White Mottled	1500–2000

American Furnaces (Coke).

Name of the State.	Total height.	Height of bosh.	Height of hearth.	Height of tuyere.	Diam. of throat.	Diam. of bosh.	Diam. at tuyere.	Volume of hearth.	Volume of etallages.	Volume of shaft.	Total volume.
Pennsylvania	12.192 to 14.325	1.904 to 3.352	.914 to 1.524	.609 to 1.219	.914 to 2.438	3.048 to 3.960	.609 to 1.524	.442 to 1.666	1.142 to 12.813	34.827 to 89.830	36.411 to 104.39

Name of the State.	Production in 24 hours	No. of c. m. in furnace by ton iron produced.	No. tons iron by met. of bosh.	No. of tuyeres.	Diam. of tuyere.	Temp. of blast.	Pressure of blast.	Kind of ore.	Yield of the ore.	Kind of iron.	Quantity of fuel to ton of cast-iron.
Pennsylvania	7.620 to 26.416	3.989 to 4.788	2.5 to 6 6	3 to 4	.076	342°	1.132 to 1.585	Lake Superior	per cent 33–62	Gray	100 bush.

Foreign Furnaces (Charcoal.)

Name of the State.	Total height.	Height of bosh.	Height of hearth.	Height of tuyeres.	Diam. of throat.	Diam. of bosh.	Diam. at tuyere.	Volume of hearth.	Volume of etallages.	Volume of shaft.	Total volume.
Nova Scotia	9.753	3.048	1.524	.533	1.015	2.743	.914	.999	4.322	29.898	25.279
Austria	8.72 to 13.97	1.58 to 4.424	.47 to 1.90	.527 to .632	.553 to 1.58	1.869 to 3.44	.67 to 1.896	.446	4.692	15.188	13 to 61.15
France	8 to 10.70	2.33 to 5	.95 to 2	.54	.60 to 1.45	1.90 to 2.75	.52 to .80	.364 to .530	2.236 to 5.059	66.993 to 14.716	11.407 to 18.960
Prussia	7.85 to 11.93	2.67 to 2.90	.42 to 1.65	....	.86 to 1.26	2.22 to 3.14	.44 to .79	....	....	....	18.33 to 30.8
Russia	6.90 to 15.70	4.84 to 6.84	.50	....	2.16 to 2.44	3.63 to 3.95	.63	.207 to .720	18.580 to 31.556	5.879 to 66.544	60.2 to 98.155
Sweden and Norway	9.75 to 12.42	3.28 to 4.70	.49 to 1.50	.42 to .61	.88 to 1.62	2 07 to 2.54	.74 to 1.25	.120 to 1.542	4.089 to 8.992	16.471 to 26.018	20.842 to 34.331
Tuscany	9 to 10.60	3.40 to 4.75	.70 to .80	....	.90 to 1.85	2.10 to 2.50	.80 to 1	.402 to .549	1.856 to 10.333	7.281 to 22.857	9.539 to 33.739

Name of the State.	Production in 24 hours	No. of c. m. in furnace by ton iron produced.	No. tons iron by met. of bosh.	No. of tuyeres.	Diam. of tuyere.	Temp. of blast.	Pressure of blast.	Kind of ore.	Yield of the ore.	Kind of iron.	Quantity of fuel to ton of cast-iron.
Nova Scotia	7.112	3.554	2.5	2	.062	92°	.340 to .453	Limonite	per cent 48	Gray White Mottled	100 bush.
Austria	2.31 to 23	2.352 to 5.667	....	2 to 5	.02 to .06	cold to 2.25°	.018 to .79				
France	2.5 to 4	3.908 to 4 125	1 to 3	.07 to .53	....	cold to 2.50°	.04 to .14	....	28–43		
Prussia	....	....	3								
Russia	22.800 to 29.352	2.155 to 2.947	2 to 12	....	....	....	....	Magnetite	67–68		
Tuscany	....	....	1–3								

Foreign Furnaces (Coke.)

Name of the State.	Total height.	Height of bosh.	Height of hearth.	Height of tuyeres.	Diam. of throat.	Diam. of bosh.	Diam. of tuyere.	Volume of hearth.	Volume of etallages.	Volume of shaft.	Total volume.
Belgium	13.26 to 18	3.50 to 5.85	2.10 to 2.87	....	2.60 to 3.80	4.12 to 5	.914 to 1.70	1.814 to 6.468	9.662 to 28.574	71.220 to 214.210	88.843 to 227.340
France	13.90 to 16	4.90 to 6.25	.85 to 2.45	.70	2 to 3	3.96 to 5	.84 to 1.80	1.218 to 5.089	17.337 to 34.111	61.695 to 134.676	80.250 to 173.876
Prussia	10.68 to 15.70	2.714 to 5.97	.659 to 2.07	....	1.897 to 2.83	3.45 to 4.71	.639 to 1.593	.211 to 2.537	9.230 to 29.855	70.364 to 101.936	78.805 to 166

Foreign Furnaces (*Coke*)—Continued.

Name of the State.	Production in 24 hours	No. of c. m. in furnace by ton iron produced.	No. tons iron by met. of bosh.	No. of tuyeres.	Diam. of tuyere.	Temp. of blast.	Pressure of blast.	Kind of ore.	Yield of the ore.	Kind of iron.	Quantity of fuel to ton of cast-iron.
Belgium	32 to 40	3.5 to 5.8	2 to 3	.08 to .14	....	....	.12 to .17	Limonite Hematite	per cent 35-40		
France.........	15 to 40	2.996 to 9.326	2 to 5	.06 to .09	....	250° to 350°	.12 to .25				
Prussia.........	7 to 30	3.266 to 7.233	3	.06 to 07	....	270° to 300°	.16 to .88				

Precautions in Building Furnaces.—In the last two years some accidents have occurred during the erection of fnrnaces. We have examined the causes in several of these cases and have fonnd that they have been attributable to the following defects and oversights :

1. *Insecure foundations.* Some engineers are not practically aware of the exceeding pressnre and weight arising from the methods of constrnction in fnrnaces and in the hoists. Some of these structures, from the conditions under which they have been erected, require a small area of base with comparatively enormous superincumbent weight. Perhaps we might have made no distinction between pressure and weight, but we think it necessary to make what we apprehend is a true distinction in this case. By weight is meant that force of gravity applied at the juncture where the generally-considered homogeneousness of material terminates, and by pressure, the same force as applied in the general structure or material itself. Allowing this definition, we would say that the weight of some furnaces of moderate size creates a formidable amount of pressure upon foundations. Is it not therefore strange, that with the addition of material of the charges, cracks and injurics occur after, if not before the blowing in? We have seen some furnace and hoist-walls give way before they were quite complete. For illustration sake. let us suppose we weigh a furnace of 50 ft. high and 12 ft. bosh, bnilded of limestone, and put np in the usual way. As the stack will be filled with material whose average density will fully cqual that of limestone, or other rock used for this purpose, we may consider its specific gravity 2.7, water being 1. Taking the latter at 60 lbs. per cubic foot, we shall have fair data to bcgin with. Snpposing the above furnace to be only 20 ft. square, on the average, to level of tunnel head, and the weight of each cubic foot to be 162 lbs., we shall have a reasonable average weight. These elements would give a weight of 1,446 tons, and the soil (if builded upon soil), would receivc, if all things were uniform, a pressure of about 56 lbs. upon the square inch. It will therefore readily be seen how easily a hoist, or furnace stack, may be injured by the yielding of even a part of the foundation, causing, as we have seen in more than one instance, a crooked wall before any fire was kindled within the works. We were informed by a gentleman who had more than fifty years of experience in building, that small stones laid in the trench excavated for walls, were more secure as a first layer than large stones, and we were referred to a large and heavy stone structure, erected more than twenty years before, in which heavy machinery had been running since its erection, and not a crack of any kind was apparent. We saw the walls of this building after they had becn subjected to a very severe fire, but no crack madc its appearance, giving additional evidence that there was no weakness in the foundations. There is much practical philosophy, unnsual as it may seem, in the laying small stones down first and letting them rnn into the ground conformably to the under surface of the large fonndation stones used in furnace constructions and their accompanying walls and hoists.

2. *Improper building material.* We have seen only one illustration of unwise economy in this respect so far as furnace works are concerned. In this case the stack and hoists became useless after being nearly completed, because of the use of a friable sandstone, taken from near at hand to save hauling from a distance. The pressure was too great for the stone. Materials are improper when the individual stones are small, especially at the corners of the structure, and they should decrease in ascending, as a matter of preference, however, and not of necessity. It is a mistake to suppose that all limestones are unfit for furnaces. Some silicious stones of that nature answer admirably when protected from fire. The conglomerates, consisting of quartz pebbles cemented with sand and aluminous silicates, form an excellent material where the adhesiveness is sufficiently great. The conglomerates of the anthracite and other regions form excellent hearthstones, and have been used most efficiently for many years, as some sandstones have been also. The composing pebbles vary from large stones to smallest pebbles, and there is no difficulty in obtaining large masses. In some placcs fire clay bricks, of large size, have been used for hearthstones with satisfactory results.

Kaolin mortar, containing soda and lime, we have good reason to suspect, is inferior. The same may be said of the fire bricks made from such matcrial. Good kaolin mortar is generally fine in texture, with little grit, and generally hardens soon, and when dry, the mortar will not rub off in gritty particles. In putting up several furnaces we had a fair trial made of kaolin clays, or fire clay cement, and have found, thus far, that the clays containing no lime or soda and partaking of the nature of silicate of alumina only, appeared to set more firmly as a mortar and remain uninjured longer as bricks. The lime-kaolins are affected comparatively more rapidly than any other. Nothing but analysis can detect it, although we have seen some powdery kaolins which were lime-kaolins, and we have suspected that this peculiarity might owe its origin to the presence of lime or soda. But when properly mixed and subjected to strong heat in a smith's fire, then kaolins are easily tested. The above are the chief causes of defects in furnace building.—*American Exchange and Review.*

Blast-Furnace Engines at the Lilleshall Company's Works.—The beams are of the horsehead class, and are 30 ft. from center to center of cylinders, and they are cast of the Lilleshall Company's cold blast iron. Each beam is composed of two flitches about 8 in. apart, the thickness of the bosses for the main centers being 9 in. The beams are supported midway between the cylinders upon an entablature 3 ft. deep resting upon four massive columns, mean diameter 17½ in. The columns and entablature, as also the nozzles, are elaborately decorated in the Doric order. The spring beams. which are of pine, 20 in. by 12 in., pass through cast iron saddles upon the entablature, and rest upon the walls of the house. The beams are 4 ft. 8 in. deep at the center. The main centers are 21 ft. 6 in. above the floor of the house. They have journals 18 in. long and 10 in. diameter, and the pummer blocks are fixed on saddles upon the entablature, and are each held down by five bolts, one bolt 3 in. diameter passing down right through the column into the foundation. The main links are 4 ft. 3 in. long between end centers, with bearings 6 in. long and 4½ in. diameter, and the radius links are connected to studs carried by brackets fixed to the spring beams.

The steam cylinders are 40 in. diameter, with a stroke of 8 ft. 6 in. They are clothed with felt and mahogany lagging, and have an ornamental packing stage round them. The piston rods are of Bessemer steel, 4¾ in. diameter, and the pistons are fitted with metallic packing. The valves are of gun-metal, of the double-beat class 10 in. diameter, and are worked by cams keyed upon a horizontal shaft below the floor, which is set in motion from the crank shaft, through the intervention of a lay shaft and bevel gearing. The steam is cut off at quarter stroke. The air pumps are 29 in. diameter and 4 ft. 3 in. stroke, and are worked by rods attached to the beams midway between the center of the cylinders and main centers. The condensers are 29 in. diameter and 5 ft. 9 in. high, the eduction pipes being led into the top. To the other end of each beam, at a distance of 4 ft. from the main center, are attached three rods bracketed together, which work respectively two 6 in. feed pumps and one 14 in. cold water pump. The connecting rods are of massive oak between two wrought iron straps 5 in. by 1⅛ in., with ⅞ in. bolts through, and fitted at each end with cast blocks, brasses, gibs, and screw cottars. They are 27 ft. 5 in. between end centers, and are coupled to the beams at a point 13 ft. 4 in. distant in a straight line from the main center. The lower ends are coupled to cast iron cranks 5 ft. 2 in. throw, the crank pins being of hammered iron, with journals 6½ in. long and 5 in. diameter. The fly-wheel is 20 ft. diameter and nineteen tons weight; the rim, which is 8 in. by 18 in., is casted in one piece. The arms, eight in number, are blocked and keyed into the rim, and the other ends are turned to fit holes in the center boss to receive them. The center is bored and keyed on the shaft. The fly-shaft has journals 18 in. long and 13 in. diameter. The seat of the wheel is 14 in. diameter. The blowing cylinders are 86 in. diameter, and samo stroke as the steam cylinders, viz: 8 ft. 6 in. Inlet valves are placed in boxes on the cylinder covers and on grids in the cylinder bases, and their combined area at one end of the cylinder is 5¼ square feet. Outlet valves are placed in wrought iron boxes at top and bottom of cylinders. Their area at one end is 1.33 square feet. These valves are made of two thicknesses of leather sewn together; and as all the inlet and outlet openings are grated, no plates or weights are required, and the valves answer the piston readily, the result being a superior blast. The piston rods are of Bessemer steel 6 in. diameter. The pistons are packed with cotton gasket —which when set hard and lubricated with black lead is found to work satisfactorily—and are cast with loose segments for convenience of packing. The blast is supplied cold to five furnaces at a pressure of 3½ lbs. per square inch, the engines running seventeen strokes per minute, with a steam pressure of 35 lbs. The blast is delivered from cylinders into wrought boxes at top and bottom of cylinders, connected by a 3 ft. wrought iron pipe, and thence through a conical pipe to the 5 ft. main, which supplies the tuyeres. There is a large opening in the engine-house in the rear of the blowing cylinders louvre-boarded to admit the air to the inlet valves. The cylinders are all firmly bedded upon stone foundations, and are each held down by four 2½ in. bolts passing down 15 ft. below the floor.

The engine-house is 58 ft. long, 25 ft. wide, and is built of stone and brick, the walls being 3 ft. thick. The engines are supplied with steam by five Cornish boilers 31 ft. long, 7 ft. 7 in. diameter, each with two 3 ft. flues through, and are fired entirely by the waste gases from one furnace.—"*The Engineer.*"

Economizing Fuel in Blast-Furnaces.—After standing for more than six months for alterations, and the putting down of new machinery, the Wingerworth Furnaces, near Chesterfield, are once more at work. Their appearance, however, is very different to what it was before the improvements to which we are about to allude took place. The old furnaces gave out the usual smoke and flame from the top, but at present, on passing, it is difficult to say whether they are in blast or not, so free are they from the usual indications one looks for. This result has been attained by taking the gas from the top, and utilizing it in a simple yet efficient manner. To effect this object, new boilers, heating-ovens, and gas apparatus, have been put down at considerable expense. The gas is conducted by a pipe to the bottom of the furnace, from whence it is sent into the boilers and heating-stoves, and there consumed instead of coal. The blast of the furnace is heated to a temperature of from 900° to 1000°, without the use of any coal whatever. The gas is taken from the top of the furnace by a process similar in many respects to that adopted at some of the works in the North of England, but somewhat different as to the mode of conducting off the gases. The alterations have given the most satisfactory results, the produce of iron from the same quantity of ore being considerably larger than by the old method, whilst the quality is also superior. The saving in fuel—an item of so much importance—has been something enormous, making a difference of many tons of coal per week, yet doing the work more efficiently. The alterations and improvements were suggested by Mr. Gjers, of

Middlesborough, and ably carried out by Mr. Marsh. The boilers, which are arranged for being worked by gas were made by the Parkgate Company. The cost of the alterations, which is considerable, will soon be repaid by the great saving in fuel, and the superior quality of the iron produced. From the many advantages of the system we think it is worthy of the consideration of iron makers in all parts of the kingdom—more especially in those districts where coal and coke have to be imported from a distance.—*Mining Journal.*

RAILWAY NOTES.

The Railways of India.—A great deal has been said and written respecting the completion of the Pacific Railway across the American continent, and much praise has been very justly bestowed upon the energy of the American character which has brought the work to its present position. While, however, we are lavish in our expressions of admiration for the great qualities which have thus been called into existence, we ought not to lose sight of the still greater works which have been accomplished in India, in the matter of railways. A vast work has been carried on silently and unobtrusively, and under difficulties even greater than any which have been experienced in regard to the Pacific Railroad, and we claim for those by whom these great works have been achieved some share of that admiration which is given so freely and so fairly to our American cousins.

The Pacific line, including as it does the two separate schemes of the Union Pacific and the Central Pacific, is about 1,700 miles in length. Two of our leading Indian lines, viz : the East Indian and the Great Indian Peninsula, at present in work, have a joint mileage of 2,230 miles, and when completed it will be 2,768 miles, greater by more than one-half of the whole length of the Pacific road. Like the Pacific, these lines cross our Indian empire from east to west, and connect Bombay and Calcutta, just as the Pacific forms the connecting link between San Francisco and New York. By means of the East Indian a railway connects Calcutta with Delhi, more than 1,000 miles distant from each other; in the south, Madras and Baypore are connected by a line crossing Southern India; Nagpore, in Central India, is connected with the port of Bombay; by means of the flotilla and Punjaub line, Lahore in the northwest, and Kurrachee in the Indus are brought into direct connection with each other. There are now actually completed and at work in India, 3,942 miles of railway, or about 600 more than the whole mileage between New York and San Francisco, and there remain to be completed of lines already sanctioned 1,665 miles. This great extent of railway has been constructed in a country many thousands of miles distant from England, where, with a trifling exception, the whole of the capital was provided. For the construction of these works there was required to be shipped from this country 3,529,000 tons of goods, of the value of £23,252,000, and which was conveyed in 5,339 ships. In America no such difficulty as this was experienced. The road, as it was formed, was enabled to carry the iron and timber required for the construction. The contractors worked from an already organized base of railways at home; the materials for the Indian lines had to be borne over thousands of miles of a sea voyage.

In both cases the Government of the country gave valuable aid to the great works. The United States Government issued their 6 per cent bonds at the rate of about £3,000 for each mile completed. In India, the Government gave its 5 per cent guarantee on the capital required. The Government of India has already paid as interest on the capital subscribed a total of £22,212,000. The amount of pecuniary assistance given by the United States Government, although large, must have been considerably less than that paid by the Indian Government, the whole amount of bonds issued not greatly exceeding £5,000,000 sterling. Of the amount paid by the Government of India in the shape of guaranteed interest, £9,500,000 has been already repaid out of the earnings of the railways over and above the guaranteed interest. The balance is to be repaid out of the half surplus profits over 5 per cent, and, judging from the results already obtained, a few years will suffice to clear off this amount of indebtedness. The position of the United States Government is by no means so favorable, as it appears that the amount of the Government bonds has been overlaid by the bonds of the company, which take precedence of the Government advances.

The construction of the Indian railways has presented difficulties of a much more formidable character than those which have been met with on the Pacific line. It is true that this railway has been carried over vast plains and mountain ranges of which little was known, and in the face of the attacks of hostile Indian tribes. In India, the works were carried out in the face of difficulties connected with the oppressive heat of the climate—through forests and jungles which were the resort of savage animals, and the people employed were natives of the country, speaking a language unknown to those by whom they were employed, and whose habits and modes of life unfitted them for labor such as that on which they were engaged. Great works such as those of the Bhore Ghaut and Thull Ghaut inclines presented difficulties equal to, if not greater, than any experienced in the crossing over the Rocky Mountains. Streams wider and more rapid than met with between Omaha and San Francisco have been successfully bridged, and present some of the greatest triumphs of modern engineering science.

While congratulating ourselves upon the results attained, so far as they affect the national character, it is not less a source of satisfaction to see how great has been the benefit already derived from railways in India. Ten years since the time occupied in traveling from Calcutta to Silma was four weeks —it took four months to march a regiment between those places; the distance is now traversed by a railway in five days. Last year 13,746,000 passengers traveled upon the Indian railways. It is worthy of notice that of this number not less than 13,074,000, or within about 700,000 of the whole number conveyed, were third class passengers. The total sum paid by railway travelers was £1,376,000. The goods traffic upon the whole of the railways yielded £3,320,000 of gross revenue. Those scruples of religion and distinctions of caste which have been for so many ages the bane of Indian society are fast disappearing before that mighty leveler of the age—the locomotive. Separate carriages or compartments were in the first instance provided for women, in deference to the feeling of dislike universally entertained at wives or daughters being seen by strangers; separate accommodation for different castes was also provided. Now all is changed, or rapidly undergoing a change. Brahmins, too, of the purest blood, travel in the third-class carriage, huddled in crowds with the most wretched Pariah, whose very presence near the household roof would in former times be regarded as the most deadly pollution. Railways, too, have been of immense service in encouraging the cultivation of cotton and other produce, in the working of iron and coal mines, by the facilities which they have afforded for bringing the produce to good markets and convenient ports for shipment. The merchant is enabled by means of the railway to deal directly with the cultivator of cotton and grain, and by this means increases the profits on their mutual transactions.

For the carrying on of the traffic upon the 3,942 miles of railway in India, there are now 937 locomotives, 2,733 passenger carriages, and 18,226 trucks and wagons, making a total of 20,959 vehicles. From the able report of Mr. Juland Danvers, we learn that there are employed on the railways of India not less than 39,099 persons, of whom 36,048 are natives.

The entire capital of £75,000,000 has been provided by 58,346 proprietors of stock and debentures, giving an average holding of about £1,300 each, and affording to them an investment scarcely less secure and much more remunerative than British Government stock. The capital estimated to be required for completing the railway system so far as it is at present sanctioned is £93,916,000. Of this sum authority has been given to raise £84,386,000, and the amount actually raised to the close of the last financial year was £76,579,000.—*Railway News.*

Railroad Frogs.—There is no portion of the permanent way of a railroad subjected to harder usage than that part of it where frogs are placed, for the purpose of effecting a crossing from one track to another. At these points the wear and tear is always more than double that of the ordinary track, and the existence of a frog has, at the best, been a precarious one, and often times but very short lived. From the primitive frog made from wrought or cast iron, we advanced to frogs with cast-iron bed plates plated with steel, riveted or bolted on, while others were of wrought-iron with movable wing rails and steel points. Then there were frogs made entirely of cast cast-steel and so arranged that when the top face of the frog was worn, it could by being simply overturned be made to live as it were, a double life. Each frog has in its generation been considered more economical than its predecessor, yet, even those of cast cast-steel—probably offering greater advantages than others preceding them—have the same objection as all cast frogs and are liable to crush under heavy weights, or break with concussion or when subjected to the effects of the severe winters of this country.

A hammered steel frog lately patented in America by Messrs. Armstrong & Co., Steel and Iron Works, Rotherham, Yorkshire, and 43 Exchange Place, N. Y., appears to possess advantages in strength and durability that other frogs do not have, and the testimony of many of the leading engineers in Europe, where the frog has been in use for three years without showing the slightest wear, leads to the believe that it is the best frog yet introduced.

The frog, as has been stated, is made from hammered crucible cast-steel, drawn from the ingot without a weld. It is reversible; is finished in the planing machine and is perfectly true to the required angle. It will neither crush nor break under heavy weights, nor with trains running at great speed. Its reliability is not decreased when subjected to severe frosts, and being of hammered metal, its elasticity prevents the rigidity felt in running over all cast crossings. When the frog has fulfilled its first purpose, the metal being necessarily a good mild steel, to bear hammering and planing, it can be sold for a large proportion of the first cost or can be converted into forgings or rolled into sheets. From a monetary point of view, this frog is more economical than the ordinary steel frog cast in moulds and, apart from this consideration, its durability is probably more than double and the reliability much increased. These frogs are also made non-reversible, an arrangement which materially reduces their first cost without decreasing their other advantages.

Messrs. Armstrong & Co. have also patented a frog composed of a cast iron bed plate with a working face of cast cast-steel. This steel facing is not riveted or bolted on, but in the process of manufacture, the two metals are incorporated, and the frog is complete in one casting. In practice it has been found, that frogs thus made are much sounder than the ordinary cast cast-iron frog and are insured perfectly free from blow-holes. They possess the recommendation of being low priced and durable. C.

Railroad *vs.* Railway.—A correspondent offers the following considerations: The use of rail*way* for rail*road* is improper—the English speaking public to the contrary, notwithstanding. The question lies in the appropriateness of *way* or *road*. The following passage from Crabbe's Synonyms, a book of the best authority, will help us in our determination.

"*Road* comes no doubt from *ride*, signifying the place where one rides. *Way* is the generic term; it is the path which a person chooses at pleasure for himself.

'He stood in the gate, and asked of every one
Which *way* she took, and whither she was gone.'
Dryden.

The *road* is the regular and beaten *way*."

Let me also quote from Gray's Synonyms, page 52: "Way is the general term, and road is the species of way. Instead of keeping the high-road to a town, you may frequently go a shorter way across the fields."

When we Americans coin a term that is correct, we should not give it up and use another because it comes from England.

Color Blindness and Railway Disasters.—One cause of railroad accidents has been discovered in England. It is what is known as color blindness. An engineer ran his train into another, causing great damage. On investigation it was found that he could not distinguish red from green, and had mistaken the signal lights.—*Exchange.*

We have an excellent way of avoiding such disasters in America—not having any signals at all.—*Ed.*

Bridges on the Pacific Railway.—Over 50 new bridges to replace temporary bridges on the Union Pacific Railroad have been built at Chicago and shipped and put up this season, and new ones will be completed over the whole line in 60 days.

Railway Consolidation.—Consolidation, which for a few years past has been the leading feature in railway strategy, is now operative upon the grandest scale. The Pacific route has given a fresh impetus to the plans by which "through bnsiness" can be facilitated and opposition set aside.

The recent combination of the roads between Boston and Albany under one direction, the plan now maturing for uniting all the lines, finished or unfinished, from Boston to Oswego, the union of the Lake Shore and the Cleveland and Toledo companies, the successive purchases and consolidations of stock by which the Chicago and Northwestern, and the Milwaukee and St. Paul railroad companies have grown to their present importance, are all examples of the rapidity with which the idea is gaining ground. These consolidations have practically enabled two great companies to control all transportation on the great middle link, *i. e.*, between Chicago and Omaha.

It is further proposed to unite in one company and under one management a continuous line of railway from New York to Omaha. This proposed corporation is to hold and administer the property and franchises now held by the Hudson River, the New York Central, the Buffalo and Erie, the Lake Shore and Cleveland and Toledo, the Michigan Southern, and the Chicago and Northwestern Railroads, including 2,480 miles of completed and equipped railway. The gross income of these companies for last year was $44,820,893.

The Pennsylvania Railroad Company leases the road of the Pittsbngh, Fort Wayne, and Chicago Railway, with all its branches, for 999 years, commencing July 1, 1869. By the terms of the lease, the former company agrees to pay the interest on the debt of the latter, and in addition thereto the sum of $1,380,000 per annum as rent for the property. The capital of the Fort Wayne Company is $11,500 000; consequently the snm of $1,380,000, named as the annual rent, is 12 per cent on the capital. The directors of the P., F. W. & C. propose to increase the amount of their stock, making the annual rent 7 per cent on the capital as increased. The P., F. W. & C. is itself a consolidation of three original companies, whose lines conjointly connected Pittsbnrgh and Chicago. It became involved in debt, and in 1861 was sold under foreclosure, the present company becoming the purchasers in 1862. This is but one step in the purpose of the Pennsylvania Railroad Company, but all reports as to other consolidations have no authority.—*American Exchange and Review.*

Turkish Railways.—In view of the great expansion of commerce which the Suez canal and the Turkish railways will create in the empire, it is proposed, among other works of magnitude, to make spacions harbors for the chief seaports, such as Constantinople—which is totally without accommodation of this kind—Salonica, etc. As regards Turkish railways, the nearest connecting point with Austria will now be Sissek, and not Brod, as formerly. Here the junction with the Southern line will be effected, and by this means the route to Trieste and Fiume, as also to Vienna and South Germany, *viâ* Northern Italy, to Southern France, will be accomplished. In the other direction the State Railway from Gross Kikinda to Belgrade will be constructed, and thence be connected with the Servian Railway.

Tests of Steel and Iron Car Wheels.—We have been furnished with the minntes of some tests made upon a cast steel car wheel, Tarr's patent, made at the "Black Diamond Steel Works," at Pittsburgh, Pa., and tested at the shops of the Pennsylvania Railway at Altoona, June 26, 1869. The test was that of the drop, weighing 1,200 lbs., falling upon the wheel, placed on bearings two feet apart, the blow on the hub :

1st blow,	9	feet	fall,	no	apparent	injnry.
2d "	11	"	"	"	"	"
3d "	14½	"	"	"	"	"
4th "	16	"	"	"	"	"
5th "	20	"	"	"	"	"
6th "	28	"	"	'	"	"
7th "	28	"	"	cracked at hub.		
8th "	28	"	"	drove hub through the plate		

of the wheel, leaving the whole tread and guard around the circumference of the wheel perfectly sound. The steel wheel weighed 444 lbs.

At the same time and place the following tests of the best iron wheels in use were made :

Ramapo,	1st	blow,	10	feet,	broke	in	many	pieces.
Lobdell,	1st	"	7	"	"	"	"	"
"	2d	"	10	"	"	"	"	"
German,	1st	"	7	"	"	"	"	"
Whitney,	1st	"	5	"	"	"	"	"
"	2d	"	7	"	"	"	"	"
Whitney,	1st	"	7	"	"	"	"	"

The cast cast iron wheels weighed 550 lbs. each. These tests are rather crude in character, but they establish the fact, pretty well known before, of the superiority of cast steel over cast iron, in resisting the effect of hard blows. A well made cast iron car wheel has an endurance on the track almost wonderfnl, but if the steel is better, safer and as economical in the end, let it be adopted by all means. At any rate let us have the real wearing tests made under the cars, and then the economical questions are easily solved.—*Railway Times.*

New Rail-Leveling Device.—The ordinary lever-bar used for lifting rails and sleepers in constructing and repairing the permanent way of railways, involves in its operation the labor of several men. To obviate this, an English engineer, Mr. De Bergue, has constructed a simple and compact tool, composed of a kind of shoe combined with a bar pivoted at one end, and at the other furnished with a screw by which it may be raised relatively to the shoe. The instrument with its bar depressed is thrust under the rail or sleeper to be raised, and the screw is turned until the bar has been forced upward sufficiently to bring the superincumbent parts to the required position. Those portions of the apparatus subjected to heavy strains are made of steel, and the working surfaces are hardened so that it cannot easily get out of repair. —*Railway Times.*

The Sliding of Car Wheels.—An experiment has been made at Munich, for the purpose of determining if a railway-carriage wheel rolls regularly without sliding, so that by recording the number of revolutions of a wheel, the circumference of which is known, the distance accomplished could be accurately ascertained. The difference between the measurement by mathematical instruments and that obtained by noting the revolutions of the wheel, was found to be no more than 1-68,000 of the whole.

WOODEN WHEELS.—Mansell's patent wheels for railway carriages are fast coming into general use. They have already been adopted by the London and North-Western, Great Western, Midland, Great Northern, Great Eastern, Metropolitan, and other English lines, and the Imperial Government has sanctioned their adoption on all the railways of Russia. It may not be generally known that Mansell's original patent was for securing the tire to the wheel by retaining rings, the fillets of which are turned to fit into corresponding grooves in the tires. The whole is secured by nuts and bolts. Between the tire and the boss, spokes are dispensed with by the insertion of stout close-fitting panels of East India teak wood, the oily nature of which preserves from oxidation the iron passing through it. For this purpose teak is superior to any other wood and it has further the advantage of never shrinking. The superiority of these wheels over iron ones is well known to all observant travelers, their special merits being absence of jarring, and also of noise.—*The Engineer.*

IRON TUBES FOR BOILERS.—There are many lines of railway on which iron tubes are found to answer as well as brass, if indeed, they do not answer better. We believe iron tubes are very largely used on the Lancashire and Yorkshire Railway, and with good succ ess. A single Birmingham house might be mentioned which has turned out 550 tons and upwards of iron tubes a month, and of these as many as 10,500 have been for locomotives, corresponding to perhaps sixty locomotives in number, although it is not to be supposed that a single house has gone on at the same rate for a year together, iron tubing, in that time, as many as seven hundred or more locomotives.—*Engineering.*

DURABILITY OF ENGLISH LOCOMOTIVES.—The life of a locomotive boiler has been found to be about 350,000 train miles, but this may probably on some lines go up to 400,000, or even 500,000 miles, as its wear and tear would depend greatly on local circumstances, and particularly on the chemical qualities of the water employed. Assuming that the life of the engine is determined by the endurance of the boiler, and that if, under favorable circumstances, it will last the 500,000 miles, then during that time the fire-box will probably require to be renewed at least three times, the tires of the wheels five or perhaps six times, the crank axles three or four times, and the tubes probably from seven to ten times.—*Herepath's Railway Journal.*

ANOTHER ALPINE RAILWAY.—Mr. Thomas Brassey, the railway contractor, has just completed his tour of inspection over the projected new railway from Innspruck, *viâ* Feldkirch, to the Bodensee, and that his opinion seems to incline in favor of the improved Fell system over the Arl mountain, instead of tunneling through it. We trust, however, for the sake of the shareholders, that there is no foundation in the report. Our own opinion of the Fell system is well known.—*Neue Freie Presse.*

CAR LOCKING IN ENGLAND.—Mr. Bentinck is about to bring under the notice of the House of Commons the practice adopted by railway companies of barring the windows and locking the doors of passenger carriages.

NEW BOOKS.

A TREATISE ON THE ART OF CONSTRUCTING OBLIQUE ARCHES WITH SPIRAL COURSES. By WM. DONALDSON, M. A. Cant., Assoc. Inst. C. E. London: E. and F. N. Spon, Charing-cross. For sale by D. Van Nostraud, New York.

The importance of works the object of which is to enable the practical man to proceed with mathematical accuracy in his business, without requiring to undertake the labor of studying pure mathematics, is more extensively acknowledged every day; whilst the continually increasing attention paid to technical knowledge by business men enables strictly scientific men to afford them the necessary theoretical aid with far greater facility than formerly. A very valuable treatise of the technical science class has just been issued by Mr. Donaldson, and will, doubtless, find a large number of patrons. The object of the author has been to arrive at a series of formulæ which would give the data necessary for the construction of oblique arches, without having recourse to any developments on a large scale, or which require skill in draughtsmanship.—He commences by explaining and demonstrating the properties of screw surfaces, and then proceeds to investigate the stability of oblique bridges, basing his investigations upon the assumptions—firstly, that the material can resist any pressure that can be put upon it; and, secondly, that for perfect security no force of shearing must be exerted upon any of the voussoirs. He explains that the forces acting on a voussoir are its own weight, a portion of the weight passing over the bridge, and the pressures on its beds. No force is exerted on the ends of a voussoir; in oblique bridges it is kept in its place by the friction on the beds. If there were no backing these forces must be in equilibrium; this is never the case where the live load is variable; they must, therefore, have a definite resultant.—We may resolve these pressures in three directions—vertical, parallel to the axis, and perpendicular to these two; the resultant of the vertical components will be eqal and opposite to the weight of the voussoir and the weight upon it, and in order that the horizontal components may satisfy the condition for perfect safety, their resultants must fall within the springing nearest to the bed to which they refer, so as to meet the material with which the bridge is backed up; also, since the pressures between the voussoir beds are mutual, the horizontal resultant of each pair must pass within each springing. He explains that the pressure at any point of a voussoir bed will act in the direction of a normal to the surface at that point, and will, therefore, lie in the normal plane to the screw line passing through that point, and will also be perpendicular to the revolving radius; and, therefore, its line of direction will be the line of intersection of the above normal plane, and a plane through that point perpendicular to the radius—the pressure at every point along this radius may be assumed to be the same. Having disposed of the question of the stability of oblique arches, Mr. Donaldson treats of the formation of templates. All the formulæ previously proved are collected together and their use explained, by working out the details of a bridge, an angle of forty-five degrees being chosen, because an instance in which the skew is very great gives the best illustration of the errors introduced by the approximate methods used. Throughout the book Mr. Donaldson displays not only an intimate knowledge of the subject on which he writes, but also a great ability in imparting that knowledge to others. The work is strictly mathematical, but a knowledge of logarithms only, and this may be acquired in five minutes by those who do not already possess it, will suffice for the practical application of the formulæ.

SOUND. By JOHN TYNDALL, L.L. D., F. R. S., Professor of Natural Philosophy in the Royal Institution of Great Britain. Second Edition. Longmans, 1867. For sale by D. Van Nostrand, New York.

That this book should have reached a second edition so soon after its appearance, does not surprise us; for even to unscientific and unmathematical readers the abstruse subjects connected with natural philosophy become not only intelligible, but fascinating in the hands of Professor Tyndall. Since the death of Faraday, Tyndall has no rival as a master of experimental science, but even Faraday was not able to set forth his philosophy in the same picturesque and charming style as his successor. At once profound and popular, elaborate yet simple, abounding with beautiful illustrations, curious truths, and striking descriptions, these lectures are in the deepest sense instructive, and in the highest degree entertaining. The work has not only excited the attention of the scientific world generally, but has won admiration from all quarters. Besides the flattering reception it has met with in this country, the book has been republished in America, while editions of it have appeared in France and Germany.

The readers of these lectures must necessarily labor under no small disadvantage as compared with those who heard them delivered and witnessed the beautiful experiments by which the subject received elucidation. But this drawback notwithstanding, the reader will still find it a delightful task to follow Professor Tyndall through his curious labyrinth of reasoning and experiment in these pages. As he himself tells us, the true physical philosopher never rests content with an inference when an experiment to verify or contravene it is possible. Accordingly, the science of acoustics is here treated experimentally throughout, and the lecturer has endeavored so to place each experiment before the reader that he may almost realize it as an actual operation. No fewer than 169 illustrations of experiments accompany the text. In a word, to give distinct images of the various phenomena of sound, and to cause them to be seen mentally in their true relations, has been Professor Tyndall's task. He has not only succeeded, but has given the world by far the most complete and valuable contribution to the science and literature of acoustics that has appeared.—*The Building News.*

WROUGHT IRON BRIDGES AND ROOFS. By W. CAWTHORNE UNWIN, B. Sc., C. E. London: Spon, 1869. For sale by Van Nostrand.

This volume contains a series of lectures delivered at the Royal Engineer Establishment, Chatham, to the officers of the Royal Engineers under instruction there; and they were afterwards printed at the press of that establishment for private circulation. That they proved useful to those for whom they were originally intended we have no doubt, and they are now offered in a revised and rearranged form to a wider circle of readers. The author assisted Mr. William Fairbairn in some of his many researches, and the work is dedicated to him. It is illustrated with examples of the calculation of stress in girders and roof trusses by graphic and algebraic methods. The author has restricted the use of symbolic expressions as much as possible; and the work holds an intermediate place between practical and theoretical treatises.—*Builder.*

TRAITÉ DE l'EXPLOITATION DES MINES DE HOUILLE etc., etc. PAR A. T. PONSON, Ingénieur civil. 2nd Edit. by JULES PONSON. Liège and Paris. 2 vols. and Atlas.

This able and complete work on coal-mining has been somewhat improved in this its second edition. It is a tolerably exhaustive treatise from the Belgian point of view of its entire subject; not better, however, than one or two French works on the same which we have ere now reviewed in these pages.

In one of its most interesting and important sections, that on shaft-sinking through water-bearing strata of running sand and mud, we observe with surprise the absence of any notice of some of the most ingenious and effective contrivances that have advanced this part of the pit-sinker's art; and this is the more remarkable, as these are of origin so close to Belgium as to be almost Flemish. The Atlas of Plates published along with the first volume, which is all we have as yet received, is well executed, and the details, both as to coal formation and the tools etc. for working coal clear and good.—*Practical Mechanics' Journal.*

TRAITÉ PRATIQUE DE l'ENTRETIEN ET DE l'EXPLOITATION DES CHEMINS DE FER. PAR CH. GOSCHLER, Ing. etc. 8vo. Baudry, Paris. 1868.

This able systematic work upon the maintenance and working of railways, the two first volumes of which we reviewed a good while ago, has now reached its third and fourth, or concluding volume. The two first, it will be recollected, treated of the material and *personnel* of railways; now we have their keeping in repair and making good use of them systematized and treated of with clearness and great practical ability.

The work ought to be a *vade mecum* to every chief servant in the employ of every railway in Great Britain, or at least all such would profit by its study; but for this a translation into English must be had, and we see on the title-page *tous droits réservés.—Practical Mechanics' Journal.*

THE DISINFECTANT QUESTION. London: M'Corquodale & Co. 1869. For sale by Van Nostrand.

Who shall review the reviewers? This question arises to us because the little work before us is a reprint of a review published in a journal called the "Sanitary Record," upon a book on disinfectants recently written by Dr. Angus Smith. The work is virtually a defense of Condy's disinfecting fluid as against McDougall's powder, which the writer says, was partly invented by Dr. A. Smith, who is therefore likely enough to speak well of it. We do not like the tone or temper of the writer. But we must confess that our experience leads us to have a great faith in the value of permanganate of potash, whether it be sold by Mr. Condy or not. It is a most valuable disinfectant and deodorizer, and when used in extremely dilute solution as a gargle, it is one of the best detergents in cases of sore throat and quinsey. Mr. Condy did not discover the permanganates, but he has certainly been instrumental in introducing them into sanitary use. His "fluids" are essentially permanganates, and they are sold in a more convenient form and at a cheaper price than they can be obtained from the chemist. This fact may in some measure justify the writer's severe strictness on the slur which Dr. Smith has cast on "Condy's fluid."—*Scientific Opinion.*

A Practical Treatise on Mill-Gearing, Wheels, Shafts, Riggers, &c., for the Use of Engineers. By Thomas Box. London: E. and F. N. Spon. For sale by Van Nostrand.

All those of our readers who possessed of Mr. Box's "Practical Hydraulics" and "Treatise on Heat" (and no engineor should be without those handy little volumes) will gladly note the publication of the work before us. Mr. Box's books are what they profess to be, practical treatises clearly written and free from all abstruse mathematical formulæ; while they are, moreover, got up in good style, and are of a convenient size for reference.—The third of the series (at least we hope that there is to be a series), bearing the title at the head of the present notice is in no way inferior to those which have preceded it. It contains, within the space of some eighty odd octavo pages, five chapters, treating respectively of the standard unit of power, of wheels, of shafts, of riggers, and of keys for wheels and riggers; the work being concluded by an Appendix. In the chapter on wheels, Mr. Box gives rules for laying out and calculating the strength of teeth, as well as for proportioning the wheels themselves, these rules being accompanied by numerous tables, which materially facilitate calculation. Similarly the chapter on shafts comprises rules for calculating the transmitting power of shafts under different conditions, together with descriptions of various methods of coupling, useful notes on plummer blocks, bearings, &c., and a section devoted to the consideration of crank shafts for driving pumps and other work. The chapter on riggers or pulleys contains a clear explanation of the action of belts accompanied by some useful tables, and also rules for the proportion of riggers of various kinds; while the fifth chapter, though brief, is equally good in its way. Finally, the Appendix contains notes on the contraction of wheels in casting, the strength of shafts and gearing for screw propellers, and the theoretical strength of shafts.

We have now briefly indicated the contents of Mr. Box's useful little treatise, and we trust we have said enough to show that it forms a valuable addition to the practical engineer's library.—*Engineering.*

The Handbook of Iron Shipbuilding. By Thomas Smith, M. I. N. A. London: E. and F. N. Spon.

It is, unfortunately, seldom that we find men eminent in their profession willing to benefit the public by their knowledge which has been acquired during many years of varied experience. It is, indeed, too generally the fact that such knowledge is jealously guarded by them, and the only method by which any one can acquire it, is to undergo similar training, and, by picking up a "wrinkle" every now and then, gradually to become proficient. In this case, however, the author, with a generous independence that cannot be too highly praised, and which evidently arises out of a certain consciousness of superiority in his profession, has given to the public a large amount of exceedingly useful information which has hitherto been most religiously kept secret. Although this work is but small, it appears to teach everything that is requisite for building an iron vessel; not only giving dimensions and a full textual explanation of every part of a ship, from the keel to the framing of the hatches, but illustrating such of these explanations as may require it, by simple drawings that it is impossible to misunderstand.

In the second part of the work, besides tables of weights and results of experiments upon the strength of ships' beams, a vast amount of information is given as to the cost of vessels of various sizes, both as regards material and wages, every detail, even to the fitting up berths, being priced separately. The author has foreseen an objection that might be urged against the usefulness of giving prices—viz: that the price of labor varies considerably in different districts—by giving examples of the cost of labor on an iron vessel, not only in London, but also on the East coast, at Liverpool and on the Clyde; thus making this portion of the work equally useful for all parts of the country. From what we have said, it will be seen that we esteem this book very highly, and consequently we strongly recommend it to all shipowners, shipbuilders, inspectors, shipmasters, foremen, and all who wish to know how a ship ought to be built or what it ought to cost.—*The Artisan.*

Der Practische Maschinen Constructeur.—A German periodical for builders of machines, engineers and manufacturers, edited by Wilhelm Heinrich Uhland, engineer and director of the Technical Institute at Frankenberg-Chemnitz, in Saxony. This excellent periodical which has entered its second year, occupies itself principally and almost exclusively with the design and construction of machines of every description. It appears twice a month. Every number contains two large cartoons printed on both sides, with beautiful partly colored drawings of machinery of the best and newest construction, general plans as well as full and explicit details, so that no manufacturer or engineer of some experience will find any difficulty in making direct practical use of them. The whole character of this periodical is, in general, eminently *practical*, abstaining from all theoretical speculations, and plainly showing the way certain kinds of machinery or certain parts of machines have to be constructed and to be put in place to give complete satisfaction to makers and uses. As but very few papers of this character exist, and as the "Maschinen Constructeur" fills its task perfectly and steadily, we do not wonder that, in spite of the short time of its existence, this paper has already acquired a vast circulation in all industrial countries. Constructors, engineers and manufacturers, even when they are not acquainted with the German language, will find the various drawings of a high value.

What is Matter? By An Inner Templar. London: Wyman & Sons. 1869. The author of this work tries to answer a question on which, as we have no testimony of a crucial nature, it is absolutely impossible to decide. Whether the substratum of phenomena be regarded as either force or matter is really of no consequence. In either case when we go beyond the mere phenomenon—the mere sensual perception—we get into the land of metaphysical abstractions. We may explain the mental impression which our senses have originated by supposing it to be the result of force or forces, or of matter having certain pre-supposed qualities, or by any other equally ingenious hypothesis; but we are as far from demonstration as ever. We confess we fail to see that "An Inner Templar" has advanced one step nearer the solution of the difficulty than those who preceded him. We have not been able, either, to ascertain very satisfactorily whether he advocates the existence of matter or force. We are quite willing to concede either to him, as being a convenient method of explaining things whose explanation we really know no more of than we do of eternity, or infinity, or atomicity. But we cannot admit, and the writer will agree with us in this, both force and matter. If in imagination we abstract force from matter, there is nothing left to conceive of. "An Inner Templar" has made no actual observations in physics, and he says he objects to mere hypotheses, as Newton did. We hope he does; but, certainly, of all the startling and wild hypotheses that we have ever met with, his own hypothesis of the origin of the salt of the sea is the most wonderful, since it is clearly evolved, like the camal of the psychologist, out of his moral consciousness. To assert as probable, that the salinity of the sea is due to the perpetual emanations of sodium, in the form of particles of matter (light) streaming from the sun, throws the old story of the "mill grinding salt" for ever into the shade. We fear a "Templar's" love of speculation drives him sometimes beyond the dull and commonplace, though still useful, region of facts. Nevertheless, we think his book contains a deal of interesting matter.—*Scientific Opinion.*

WORSSAM & CO.'S ILLUSTRATED CATALOGUE OF WOOD-WORKING MAHINERY, OAKLEY WORKS, KING'S ROAD, CHELSEA. Folio, 1869. Illustrated.

This is one of the most copious, complete, and handsomely got-up trade catalogues of any British tool-making establishment that we have seen. Dimensions, weights, speeds, power to drive, work done per hour, &c. by most of the tools are given, and the Catalogue is really a very good and valuable practical guide to wood-working machinery of the best and most recent descriptions.

Although by title limited to wood-working machine tools, in reality it is still more comprehensive, and embraces punching-presses, crab and crane machinery, marble-sawing and grinding machinery, mortar mills and several others, which the issuing house have made their specialities.—*Practical Mechanic's Journal.*

THE STEPPING STONE TO ARCHITECTUE. By T. MITCHELL. Longmans. For sale by D. Van Nostrand, New York.

This little book forms one of what the publishers designate their "Stepping Stone to Knowledge Series," addressed to the young. It may be called a Catechism of Architecture, after the manner of the well-known Pinnock, being a series of questions and answers on the history and different orders and styles of architecture, ancient, mediæval and modern, "compiled with the view of creating a taste in the mind of the young for the noblest of the arts."—The publication, however, may also prove serviceable to some who are more advanced, since it gives upwards of a score of plates, and about fifty figures taken from "Gwilt's Encyclopædia of Architecture."—*Building News.*

A DICTIONARY, PRACTICAL, THEORETICAL AND HISTORICAL, OF COMMERCE AND COMMERCIAL NAVIGATION. By the late J. R. M'CULLOCH. With a biographical notice. New edition by Hugh G. Reid. Longmans. 1869.

This is a new and enlarged edition of a standard work, containing not less than 1,600 pages of matter. It is well spoken of by the English authorities.

INVENTORS' AND MANUFACTURERS' GAZETTE. E. H. SALTIEL, New York. This is a new dollar monthly, containg ten pages of text and many wood engravings.

MISCELLANEOUS.

JOHN A. ROEBLING.—Mr. Roebling was by birth a Prussian. He was a distinguished pupil of the Royal Polytechnic School of Berlin. The subject of his thesis, upon graduating from that institution, was "Suspension-Bridges"—a subject which made his after life famous, his death glorious, and which will give to his memory a fullness and freshness that cannot pass away. After having been engaged for three years, in accordance with a Governmental regulation, upon the public works in Germany, he emigrated to America. Arriving at Pittsburg, he settled upon a small tract of land, and devoted his attention for a while to agricultural pursuits. About the year 1830, the onward movement in the tide of American engineering affairs set in with all its force, and the young agriculturist was taken up by the first incoming wave. The plough and the harrow, the scythe and the sickle must needs give way to the compass and level, the rod and the chain. He was employed for some time on the various canals and other works at that time being carried on in every direction. With great forethought, he commenced the manufacture of wire-rope, doubtless instigated thereto by a recollection of his early love of the subject of suspension-bridges. The year 1844 records his first work of that class—to wit, the construction of a wooden aqueduct across the Alleghany River, which he carried out on the wire-rope suspension principle, with great success. The construction of the suspension-bridge over the Monongahela at Pittsburg, the site of his early agricultural labors, followed. The erection of suspension-brigdges in various localities so far enlarged his experience as to induce him to undertake the apparently impossible task of spanning the Niagara, near the falls, with a railway suspension-bridge. This, his greatest achievement, was completed in 1855, and, for boldness in conception, economy in construction, and proportionate strength in all its parts is, perhaps, unsurpassed by any engineering work of modern times.

His designs of the East River Bridge, the plans of which he had thoroughly matured, and which have withstood the test of the severest criticism at the hands of the ablest engineering talent of the country, are left as the last, and perhaps the greatest, monument of his engineering skill in coping with physical obstacles that to other less bold and comprehensive minds would have proved insurmountable. In the crypt of St. Paul's Cathedral is a simple slab that marks the tomb of its great designer, Sir Christopher Wren. Upon the slab are inscribed, in effect, these words: "If you would seek his monument, look around you." Thus it is with John A. Roebling; his works are an imperishable monument to his memory—*Engineering and Mining Journal.*

The Great Eastern.—When the eminent engineer, Brunel, built the Great Eastern, he expected to begin a new era in commerce. He supposed his vessel would carry freight and passengers cheaper and more expeditiously and comfortably than other vessels, and that he should work a revolution in shipbuilding and trade. Her first voyage to New York was a failure. She seemed to be an utter failure, and good for nothing. Poor Brunel died of chagrin and disappointment.—*Exchange.*

This is a specimen of the information given to the public about this wonderful ship, by commercial newspapers. Brunel conceived the idea of the Great Eastern, and arranged her double propelling power, but he did not build her, nor did he, in a naval architectural sense, design her. This was Scott Russell's work. That she will carry freight 100 per cent more cheaply than smaller vessels, when fully loaded, is not questioned by experts, and has in fact been demonstrated by the results of other ships of different sizes. The Great Eastern will hold eight times the freight and encounter only four times the resistance, at a given speed, of a vessel of half her length, breadth and depth. As to carrying passengers more comfortably—she has always demonstrated this, except in one case, when she was so ballasted as to roll abnormally. Any ship can be served so. We have sailed as quietly upon her, in mid ocean, as upon Long Island Sound steamers in average weather, and at a time, too, when the vessels passing the Great Eastern were pitching so much as to cause general sea-sickness. The Great Eastern was never filled nor never run on the route for which she was built. It is not probable that the "Scotia" would pay between Boston and New York, immense as the traffic is. How was the first voyage of the ship to New York a failure? We made that voyage in good average time, taking a long detour ; and no one was seasick, though there were two days of heavy weather. The good-for-nothingness of the Great Eastern has been demonstrated by her laying three cables and uniting two continents—a work that would not have been done without her. Finally, Brunel died before she was launched, and consequently not in consequence of her unprofitable voyages, which were, by the way, the result of bad management. We commend these considerations to the penny-a-liners who periodically pitch into the Great Eastern.

The British Telegraph Bill.—The bill for the purchase of the telegraphic lines throughout Great Britain is a measure of great importance. The Government purpose extending telegraphic communication to the suburbs of all the large towns, to all the second-rate towns having railway stations, and to places in which at present there are neither telegraph nor railway stations. It is contemplated to serve, under the new arrangement, 3,376 places, instead of 1,882 now served by telegraphs and railways, and to have 842 branch offices, instead of the 247 existing at present. There is now one telegraph office to every 13,000 of the population; the Government will have one office to every 6.000 of the population. They propose, likewise, the creation of offices of deposit, every letter-box and every pillar-box being such an office, where messages will be received and sent to the telegraph office to be forwarded to their destination. The wires are to be brought into the money order office in every town and district, thereby bringing the telegraph into the center of a population, instead of its remaining, as it frequently does at present, in the outskirts. And they contemplate extending in many places the number of hours during which the telegraph will be accessible to the public. It is proposed also to have one uniform tariff of 1s. for 20 words. The basis of the agreement entered into, under an act passed last year, for the transfer of the lines to the Government, was that a sum amounting to twenty years' purchase of the net profits of the various telegraph companies up the 30th of June of last year should be paid to the proprietors of those undertakings. On this basis the amount to be paid to the companies is over $28,500,000 gold, but other expenses will swell the total cost to $33,500,000. It is expected that the lines will yield a gross revenue close upon $3,500,000, and the expenditure will be nearly $2,000,000, showing about $1,500,000 net profit—enough to pay the interest upon the purchase money and leave a surplus of fully $250,000. The number of inland messages for the year ending last December was 6,000,000, upon which number it is reckoned there will be an increase for the first year of at least 2,500,000. Much of this increase is expected to result from bringing the telegraph nearer the center of the population; experience, both on the continent and in England, having shown that wherever telegraph facilities are by this means placed within easy reach of the people, a large increase on the number of messages is certain to follow. It is noteworthy that, contrary to the opinion of some of the most experienced engineers, the Government, in the estimates, have calculated the life of a cable at fifteen years, and have therefore provided for replacing all the cables at the end of that time.—*Tribune.*

The Darien Canal—An Old Project.—The project of uniting the two oceans by a cut across the Isthmus of Darien, is not a new or a modern one. In 1528 a route for a canal was examined by two Flemish engineers, by the orders of Philip II of Spain, but finding insuperable difficulties, the project was abandoned. In England the project was revived in the latter part of the seventeenth century. In 1826, Domingo Lopez, of New Granada, explored a route for a canal 44 miles in length, between Panama and Portobello. Another survey was made in 1827, under the orders of General Bolivar, by two English engineers, Lloyd and Falmark, who concluded their labors in 1829. The only result of their labors was proving the possibility of either a canal or railroad between Panama and Chagres. In 1843, the French government sent out MM. Garella and Courtines to make explorations. They reported in favor of a canal passing under the dividing ridge of the Ahogayegua by a tunnel 125 feet high from water level, and 17,390 feet long.

Napoleon and the Engineers.—The Emperor Napoleon in his early days was an enthusiastic student of engineering science and an engineer of no mean acquirements; and since his elevation to the throne has shown himself constantly the friend, patron and promoter of all ingenious inventions, and especially of all enterprises embodying the science of construction in public ways and works of all kinds. It is no mere empty compliment, then, that has been offered him by the London Institution of Civil Engineers in electing him an honorary member of that body; and the cordial reception which the Emperor gave the Committee who bore to him official information of it, meant, doubtless, more of genuine pleasure and cordiality than could be found in most international forms of courtesy.—*Y. Y. Times.*

Morton's Ejector-Condenser.—This novel appliance to the steam engine (described and illustrated in Van Nostrand's Magazine, No. 3, p. 225), is making rapid and extensive progress amongst engineers, mine owners, and others. Orders for the condenser and for licenses to manufacture it are being received from all parts of the United Kingdom. No fewer than four condensers were sent off last week to meet as many orders. One has lately been applied to a pumping engine at a colliery belonging to Messrs. Wilsons & Co., of Summerlee Ironworks, and the consumption of coal in six hours was immediately reduced from 56 cwt. to 33 cwt. A more striking instance of economy of fuel effected by using a Morton condenser is that afforded by an engine to which the condenser was applied, near Dalry, in Ayrshire. The consumption of fuel was reduced one-half. So satisfied is the manager of the works (Messrs. Merry and Cunninghame's) with the work done by this condenser, that it is intended to apply the apparatus to several other engines. It has been applied to a Clyde-built screw steamer, lately purchased for the Pontifical Marine, and Messrs. Day & Co., Southampton, have just built a splendid steam yacht, to whose engines it has been applied. In this instance the condenser has been constructed of finely polished gun-metal. —*Engineering.*

Welded Boilers.—A contract was recently let to a Belgian firm for the making of twenty boilers thirteen feet long and three and a half in diameter—the whole to be of half-inch plates, and to be *welded* throughout. No English firm would take the contract.—*Exchange.*

It would be interesting to know whether these boilers are to be welded by Bertram's gas welding process or some modification of it. We can hardly imagine how a perfect job can be made otherwise. We have seen at Woolwich a complex boiler completely and soundly welded by this process.

Mr. Isherwood and General Grant.—Speaking of the President's nomination of chief engineer James W. King to be chief of the Bureau of Steam Engineering, "in place of Isherwood, whom I desire removed," the Engineer says: "We are sorry that Mr. Isherwood has been removed. He was the right man in the right place as far as England was concerned."

Shipping of Liverpool.—The quantity of shipping for sale in the port of Liverpool now amounts to the enormous aggregate of 124,788 tons, thus classified:—Colonial built sailing ships, 39,510 tons; British built ditto, wood, 18,464 tons; ditto iron, 5,266 tons; foreign built, sailing ships, 10,943 tons; new sailing ships, iron and composite, 4,590 tons; screw steamers, 38,180 tons; paddle steamers. 7,835 tons.

Marine Engines.—Messrs. Maudslay, Sons and Field, are completing three pairs of 800-horse power engines for foreign governments. Messrs. John Penn and Son are actively engaged upon the 1200-horse power engines of the Sultan—copies in every respect of the engines of the Hercules. The great crank shaft was forged by Messrs. Rigby and Beardmore, of the Parkhead Forge, Glasgow. It has turned out, in the lathe, as sound a forging as any ever made. Its weight, in the rough, was nearly 35 tons.

Boiler Explosions.—No one doubts that a series of comprehensive experiments conducted by our most competent experts, and costing say $100,000, would develop the causes and remedies for these disasters; yet boiler owners go on blowing up millions of money—not to speak of lives—every year, without spending a cent or making a movement towards a radical cure. So long as the causes of explosions cannot be proved and demonstrated to be simple and accessible, rather than mysterious and remote, so long will there be excuses for mal-construction and mal-practice.

Aerial Navigation.—Upon the heels of the meeting of the British Æronautical Society, which developed little but hopes based upon failures, we have news from California that the great problem is solved. Let us hope so. At the same time, it is difficult to see, with the light we now have, how all the talent, patience and money expended in this direction in England, can have so utterly missed the great possibilities upon which the California inventor has so easily seized.

Ocean Time of the "Dauntless."—The American yacht "Dauntless," Vice Commodore James G. Bennett, jun., recently made the run, from New York to Queenstown, in 12 days 17 hours 6 min. 12 sec., and beating the time of the "Henrietta" in her famous ocean race with the "Fleetwing" and "Vesta." The "Dauntless" experienced heavy weather the entire voyage.

American Running Gear Abroad.—An English firm of coachbuilders announce that they are prepared to build light carriages on wheels imported from America. Now that this innovation has been made it is just possible that the principle of light wheels will be applied to the construction of carts and wagons used in agricultural districts.

Duty of Cornish Engines in England.—Eighteen Cornish engines were reported in April. These consumed 1,468 tons of coal, and lifted 11,700,000 tons of water ten fathoms high. Average duty, 53,700,000 lbs., lifted one foot high by the consumption of 112 lbs. of coal. Seven engines exceeded the average duty.

Neutralizing Miasmatic Gases.—The plan of neutralizing the effects of marshy extralations tried in the fens near Rochefort, and in Holland, with success, is about to be introduced into Lincolnshire. It consists in the cultivation of the sunflower on a large scale.

Large Pumping Engine.—The "Scientific American" states that the third pumping engine for the Brooklyn Waterworks, now being built, will be the largest and most powerful pumping engine in the world, with the exception of one in Cincinnati.

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MODERN MECHANICAL SCIENCE.

From the inaugural address of C. W. Siemens, F. R. S., before Section G (Mechanical Science Section) of the British Association, August 19, 1869.

In prefacing our proceedings with a few remarks on the leading subjects of the day of special interest to our section, I can scarcely pass over the somewhat hackneyed question of technical education.

Technical Education.—The great international exhibitions proved, that although England still holds her ground as the leading manufacturing country, the nations of the Continent have made great strides to dispute her pre-eminence in several branches, a result which is generally ascribed to their superior system of technical education. Those desirous of obtaining a clear insight into that system, and the vast scale upon which it is being carried out under Government supervision, cannot do better than read Mr. John Scott Russell's very able volume on this subject, and they will, no doubt, agree with the author in the necessity of energetic steps being taken in this country to promote the work of universal education. Although I, for one, think that objection may fairly be made against the plan of merely imitating the example of our neighbors.

The polytechnic schools of the Continent, not satisfied to impart to the technical student a good knowledge of mathematics and of natural sciences, pretend, also, to superadd the practical information necessary to constitute them engineers or manufacturers.

This practical information is conveyed to them by professors, lacking themselves practical experience, and tends to engender in the students a dogmatical conceit, which is likely to stand in the way of originality in the adaptation of new means to new ends in their future career. On this account, I should prefer to see a sound "fundamental" education, comprising mathematics, dynamics, chemistry, geology and physical science, with a sketch only of the technical arts, followed up by professional training, such as can only be obtained in the workshop, the office or the field.

Patents.—Closely allied to the question of education is that of the system of Letters Patent. A patent is, according to modern views, a contract between the Commonwealth and an individual who has discovered a method, peculiar to himself, of accomplishing a result of general utility. The State, being interested to secure the information, and to induce the inventor to put his invention into practice, grants him the exclusive right of practising it, or of authorizing others to do so, for a limited number of years, in consideration of his making a full and sufficient description of the same. Unfortunately, this simple and equitable theory of the patent system is very imperfectly carried out, and is beset with various objectionable practices, which render a patent sometimes an impediment to, rather than a furtherance of applied science, and sometimes involves the author of an invention in endless legal contentions and disaster, instead of procuring for him the intended reward. These evils are so great and palpable, that many persons, including men of undoubted sincerity and sound judgment on most subjects, advocate the entire abolition of the Patent Laws. They argue that the desire to publish the results of our mental labor suffices to ensure to the Commonwealth the possession of all new discoveries or inventions, and that justice might be done to meritorious inventors by giving them national rewards.

This argument may hold good as regards a scientific discovery, where the labor bestowed is purely mental, and carries with it the pleasurable excitement peculiar to the exercise and advancement of science on the part of the devotee ; but a practical invention has to be regarded as the result of a first conception, elaborated by experiments and their application to existing processes in the face of practical difficulties, of prejudice, and of various discouragements, involving also great expenditure of time and money, which no man can well afford to give away, nor can men of merit be expected to advocate their cause before the national tribunal of rewards, where at best only very narrow and imperfect views of the ultimate importance of a new invention would be taken, not to speak of the favoritism to which the doors would be thrown open. Practical men would undoubtedly prefer either to exercise their inventions in secret, where that is possible, or to desist from following up their ideas to the point of their practical realization. If we review the progress of the technical arts of our time, we may trace important practical inventions almost without exception to the Patent Office. In cases where the inventor of a machine or process, happened to belong to a nation without an efficient patent law, we find that he readily transferred the scene of his activity to the country offering him the greatest encouragement, there to swell the ranks of intelligent workers. Whether we look upon the powerful appliances that fashion shapeless masses of iron and steel into railway wheels or axles, or into the more delicate parts of machinery ; whether we look upon the complex machinery in our cotton factories, our dye works and paper mills, or into a Birmingham manufactory, where steel pens, buttons, pens, buckles, screws, pencil-cases, and other objects of general utility are produced by carefully elaborated machinery, at an extremely low cost ; or whether we look upon our agricultural machinery, by which England is enabled to compete, without protection, against the Russian or Danubian agriculturist, with cheap labor and cheap land to back him, in nearly all cases we find that the machine has been designed and elaborated in its details by a patentee who did not rest satisfied till he had persuaded the manufacturers to adopt the same, and removed all their real or imaginary objections to the innovation. We also find that the knowledge of its construction reaches the public directly or indirectly through the Patent Office, thus enlarging the basis for further inventive progress.

The greatest illustration of the beneficial working of the patent laws, was supplied, in my opinion, by James Watt, when, just about 100 years ago, he patented his invention of a hot working cylinder and separate steam engine condenser. After years of contest against those adverse circumstances that beset every important innovation, James Watt, with failing health and scanty means, was only upheld in his struggle by the deep conviction of the ultimate triumph of his cause. This conviction gave him confidence to enlist the co-operation of a second capitalist, after the first had failed him, and of asking for an extension of his declining patent.

Without this opportune help Watt could not have succeeded to mature his invention ; he would, in all probability, have relapsed into the mere instrument maker, with broken health and broken heart, and the invention of the steam engine would not only have been retarded for a generation or two, but its final progress would have been based probably upon the coarser conceptions of Papin, Savory and Newcomen.

It can easily be shown that the perfect conception of the physical nature of steam, which dwelt like a Heaven-born inspiration in Watt's mind, was neither understood by his contemporanies nor by his followers, up to very recent times ; nor can it be gathered from Watt's very imperfect specification. James Watt was not satisfied to exclude the condensing water from his working cylinder, and to surround the same by non-conducting substances, but he placed between the cylinder and the non-conducting envelope, a source of heat in the form of a steam jacket, filled with steam at a pressure somewhat superior to that of the working steam. His successors have not only discarded the steam jacket, and even condemned it on the superficial plea that the jacket presented a larger and hotter surface for loss by radiation than the cylinder, but expansive working was actually rejected by some of them on the ground that no practical advantage could be obtained by it. The modern engine, notwithstanding our perfected means of construction, had in fact degenerated in many instances into a simple steam-meter, constructed apparently with a view of emptying the boiler in the shortest possible space of time.

It is only during the last twenty years that the subtile action of saturated steam in condensing upon the sides of the cylinder when under pressure, and of evaporating when the pressure is relieved toward the end of each stroke, has been again recognized and insisted upon by Lechatelier and others, who have shown the necessity of a slightly super-heated cylinder in order to realize the expansive force of steam.

The result has been a reduction in the consumption of fuel in our best marine engines from 6 to 8 to below 3 lbs. per gross indicated horse power.

Would it be safe in view of such facts as these to discard the patent laws which, as I have endeavored to show, lay at the very foundation of our modern progress, without making at all events a serious effort to remedy those evils, which, it is admitted on all hands, now adhere to them? These evils need for the most part no special legislation, but can be traced to the imperfect manner in which the existing patent laws are carried into effect.

It is a hopeful circumstance that during the next session of Parliament, the whole question of the patent laws is likely to be inquired into by a special committee, who, it is to be hoped, will act decidedly in the general interest, without being influenced by special or professional claims. They will have it in their power to render the Patent Office an educational institution of the highest order.

The Great Works of the Year.—In viewing the latest achievements of engineering science, two works strike the imagination chiefly by their exceeding magnitude, and by the influence they are likely to exercise upon the traffic of the world. The first of these is the great Pacific Railway, which, in passing through vast regions hitherto inaccessible to civilized man, and over formidable mountain chains, joins California with the Atlantic States of the great American republic. The second is the Suez shipping canal, which, notwithstanding adverse prognostications and serious difficulties, will be opened very shortly to the commerce of the world. These works must greatly extend the range of commercial enterprise in the North Pacific and the Indian Seas. The new waterway to India, will, owing to the difficult navigation of the Red Sea, be in effect only available for ships propelled by steam, and will give a stimulus to that branch of engineering.

Telegraphs.—Telegraph communication with America has been rendered more secure against interruption by the successful submersion of the French Transatlantic Cable. On the other hand, telegraphic communication with India still remains in a very unsatisfactory condition, owing to imperfect lines and divided administration.

To supply a remedy for this public evil, the Indo-European Telegraph Company will shortly open its special lines for Indian correspondence. In Northern Russia, the construction of a land line is far advanced to connect St. Petersburg with the mouth of the Amour river, on completion of which only a submarine link between the Amour and San Francisco will be wanting to complete the telegraphic girdle round the earth.

With these great highways of speech once established, a network of submarine and aërial wires will soon follow, to bind all inhabited portions of our globe together into a closer community of interests, which, if followed up by steam communication by land and by sea, will open out a great and meritorious field for the activity of the civil and mechanical engineer.

Railways.—But while great works have to be carried out in distant parts, still more remains to be accomplished nearer home. The railway of to-day has not only taken the place of high roads and canals, for the transmission of goods and passengers between our great centers of industry and population, but is already superseding by-roads leading to places of inferior importance; it competes with the mule in carrying minerals over mountain passes, and with the omnibuses in our great cities. If a river cannot be spanned by a bridge without hindering navigation, a tunnel is forthwith in contemplation; or, if that should not be practicable, the transit of trains is yet accomplished by the establishment of a large steam ferry.

It is one of the questions of the day to decide by which plan the British Channel should be crossed, to relieve the unfortunate traveler to the Continent of the exceeding discomfort and delay inseparable from the existing most imperfect arrangements. Considering that this question has now been taken up by some of our leading engineers, and is also entertained by the two interested

Governments, we may look forward to its speedy and satisfactory solution.

So long as the attention of railway engineers was confined to the construction of main lines, it was necessary for them to provide for a heavy traffic and high speeds, and these desiderata are best met by a level, permanent way, by easy curves, and heavy rails of the strongest possible materials, namely, cast steel, but in extending the system to the corners of the earth, cheapness of construction and maintenance, for a moderate speed, and a moderate amount of traffic, become a matter of necessity.

Instead of plunging through hill and mountain, and of crossing and recrossing rivers by a series of monumental works, the modern railway passes in zigzag up the steep incline, and conforms to the windings of the narrow gorge; it can only be worked by light rolling stock of flexible construction, furnished with increased power of adhesion and great brake power. Yet, by the aid of the electric telegraph, in regulating the progress of each train, the number of trains may be so increased as to produce, nevertheless, a large aggregate of traffic, and it is held by some that our trunk lines even would be worked more advantageously by light rolling stock.

The brake power on several of the French and Spanish railways has been greatly increased by an ingenious arrangement, conceived by M. Lechatelier, of applying what has been termed "contre vapeur" to the engine, converting it for the time being into a pump forcing steam and water into the boiler.

Warfare.—While the extension of communication occupies the attention of perhaps the greater number of our engineers, others are engaged upon weapons of offensive and defensive warfare. We have scarcely recovered our wonder at the terrific destruction dealt by the Armstrong gun, the Whitworth bolt, or the steel barrel consolidated under Krupp's gigantic steam hammer, when we hear of a shield of such solidity and toughness, as to bid defiance to them all. A larger gun, or a hard bolt by Palliser or Gruson, is the successful answer to this challenge, when again defensive plating, of greater tenacity to absorb the power residing in the shot, or of such imposing weight and hardness combined as to resist the projectile absolutely (causing it to be broken up by the force residing within itself), is brought forward.

The ram of war with heavy iron sides, which a few years since was thought the most formidable, as it certainly was the most costly weapon ever devised, is already being superseded by vessels of the Captain type, as designed by Captain Coles, and ably carried out by Laird Brothers, with turrets (armed with guns of gigantic power) that resist the heaviest firing, both on account of their extraordinary thickness, and of the angular direction in which the shot is likely to strike.

By an ingenious device Captain Moncrieff lowers his gun upon its rocking carriage after firing, and thereby does away with embrasures (the weak place in protecting works), while at the same time he gains the advantage of reloading his gun in comparative safety.

It is presumed that in thus raising formidable engines of offensive and defensive warfare, the civilized nations of the earth will pause before putting them into earnest operation, but if they should do so, it is consolatory to think that they could not work them for long without effecting the total exhaustion of their treasuries, already drained to the utmost in their construction.

Iron and Steel.—While science and mechanical skill combine to produce these wondrous results, the germs of further and still greater achievements are matured in our mechanical workshops, in our forges, and in a metallurgical smelting works; it is there that the materials of construction are prepared, refined and put into such forms as to render greater and still greater ends attainable. Here a great revolution of our constructive art has been prepared by the production, in large quantities, and at moderate cost, of a material of more than twice the strength of iron, which, instead of being fibrous, has its full strength in every direction, and which can be modulated to every degree of ductility, approaching the hardness of the diamond on the one hand, and the proverbial toughness of leather on the other. To call this material cast steel seems to attribute to it brittleness and uncertainty of temper, which, however, are by no means its necessary characteristics. This new material, as prepared for constructive purposes, may, indeed, be both hard and tough, as is illustrated by the hard steel rope that has so materially contributed to the practical success of steam ploughing. Machinery steel has gradually come into use since about 1850, when Krupp, of Essen, commenced to supply large ingots that were shaped into railway tyres, axles, cannon, &c., by melting steel in furnaces containing hundreds of melting crucibles.

The Bessemer process, in dispensing with the process of puddling, and in utilizing the carbon contained in the pig iron to effect the fusion of the final metal, has given a vast extension to the application of cast steel for railway bars, tyres, boiler plates, &c.

The process is limited, however, in its application to superior brands of pig iron, containing much carbon, and no sulphur or phosphorus, which latter impurities are so destructive to the quality of steel. The puddling process has still to be resorted to, to purify these inferior pig irons, which constitute the bulk of our productions, and the puddled iron cannot be brought to the condition of cast steel except through the probess of fusion. This is accomplished successfully in masses of from 3 to 5 tons on the open bed of a regenerative gas furnace, at the Landore Siemens Steel Works, and at other places. At the same works cast steel is also produced, to a limited extent as yet, from iron ore, which, being operated upon in large masses, is reduced to the metallic state, and liquified by the aid of a certain proportion of pig metal. The regenerative gas furnace, the application of which, to glass houses, to forges, &c., has made considerable progress, is unquestionably well suited for this operation, because it combines an intensity of heat, limited only by the point of fusion of the most refractory material, with extreme mildness of draught and chemical neutrality of flame.

These and other processes of recent origin, tend toward the production, at a comparatively cheap rate, of a very high class material, that must shortly supersede iron for almost all structural purposes. As yet engineers hesitate, and very properly so, to construct their bridges, their vessels, and their rolling stock, of the material produced by these processes, because no exhaustive experiments have been published as yet, fixing the limit to which they may safely be loaded in extension, in compression and in torison, and because they have as yet no sufficient information regarding the tests by which their quality can best be ascertained. This great want is in a fair way of being supplied by the experimental researches that have been carried on for some time at Her Majesty's dockyards at Woolwich, under a committee appointed for that purpose by the Institution of Civil Engineers. In the meantime excellent service has been rendered by Mr. Kirkaldy, in giving us, in a perfectly reliable manner, the resisting power and ductility of any sample of material which we wish to submit to his tests. The results of Mr. Whitworth's experiments, tending to render the hammer and the rolls obsolete, by forcing cast steel, while in a semi-fluid state, into strong iron moulds by hydraulic pressure, are looked upon with great interest. But assuming that the new building material has been reduced to the utmost degree of uniformity and cheapness, and that its limits of strength are fully ascertained, there remains still the task for the civil and mechanical engineer to prepare designs suitable for the development of its peculiar qualities. If in constructing a girder, for example, a design were to be adopted that had been worked out for iron, and if all the scantlings were simply reduced in the inverse proportion of the absolute and relative strength of the new material as compared with iron, such a girder would assuredly collapse when the test weight was applied, for the simple reason that the reduced sectional area of each part, in proportion to its length, would be insufficient to give stiffness. You might as well almost take a design for a wooden structure, and carry it out in iron, by simply reducing the section of each part. The advantages of using the stronger material become most apparent, if applied, for instance, to large bridges, where the principal strain upon each part is produced by the weight of the structure itself; for supposing that the new material can be safely weighted to double the bearing strain of iron, and that the weight of the structure were reduced by one-half accordingly, there would still remain a large excess of available strength, in consequence of the reduced total weight, and this would justify a further reduction of the amount of the material employed. In constructing works in foreign parts, the reduced cost of carriage furnishes also a powerful argument in favor of the stronger material, although its price per ton might largely exceed that of iron.

Coal and Power.—The inquiries of the Royal Commission into the extent and management of our coalfields, appear to be reassuring as regards the danger of their becoming soon exhausted; nevertheless, the importance of economizing these precious deposits in the production of steam power in metallurgical operations, and in domestic use, can hardly be overestimated. The calorific power residing in a pound of coal of a given analysis, can now be accurately expressed in units of heat, which again are represented by equivalent units of force, or of chemical action; therefore, if we ascertain the consumption of coal of a steam engine, or of a furnace employed in metallurgical operations, we are able to tell by the light of physical science, what proportion of the heat of combustion is utilized, and what proportion is lost. Having arrived at this point, we can also trace the channels through which loss takes place, and in diminishing these by judicious improvement, we shall more and more approach those standards of ultimate perfection which we can never reach, but which we should nevertheless keep steadfastly before our eyes. Thus a pound of ordinary coal is capable of producing 12,000 Fahrenheit units of heat, which equal 9,264,000 foot-pounds or units of force, whereas the very best performances of our pumping engines do not exceed the limit of 1,000,000 foot-pounds of force per pound of coal. In like manner 1 lb. of coal should be capable of heating 33 lbs. of iron to the welding point of say 3000° Fahr., whereas in an ordinary furnace not 2 lbs. of iron are so heated with 1 lb. of coal. These figures serve to show the great field for further improvement that lays yet before us.

Refrigeration.—Although heat may be said to be the moving principle by which all things in nature are accomplished, an excess of it is not only hurtful to some of our processes, such as brewing, and destructive to our nutriments, but to those living in hot climates, or sitting in crowded rooms, an excess of temperature is fully as great a source of discomfort as excessive cold can be. Why, then, may I ask, should we not resort to refrigeration in summer, as well as to calorification in winter, if it can be shown that the one can be done at nearly the same cost as the other? So long as we rely for refrigeration upon our ice cellars, or upon importation of ice from distant parts, we shall have to look upon refrigeration as a costly luxury only, but by the use of properly constructed machines it will be possible, I believe, to produce refrigeration at an extremely moderate expenditure of fuel and labor. A machine has already been constructed capable of producing 9 lbs. of ice or its equivalent for 1 lb. of coal, whereas the equivalent values of positive heat developed in the combustion of 1 lb. of coal, and of negative heat residing in 1 lb. of ice, is about as 12,000 to 170, or as 1 to 70. This result already justifies the employment of refrigerating machines upon a large scale, but it is hard to say what practical results may yet be reached with an improved machine on strictly dynamical principles, because such a machine seems not tied in its results to any definite limits. In changing, for instance, a pound of water from the liquid into the gaseous state, a given number of units of heat are required, that may be produced by combustion of coal or by the expenditure of force, but in changing the same pound of water into ice, heat is not lost but gained in the operation, which heat must be traceable to another part of the machine, either as sensible heat or as developed force. It would lead me too far to enter at present into particulars on this question, which is one not without interest for the physicist and the mechanical engineer.

SEA COAST DEFENSE.

THE MONCRIEFF SYSTEM OF WORKING ARTILLERY.

From a paper by Captain Moncrieff, before the Royal Institution of Great Britain.

Until the time of the Crimean war very little and very slow progress had been made in artillery. Canon were manufactured on nearly the same models, and of the same materials, that had been used for 300 years. Before that time cast-iron was not in use, but the forged or bronze guns, although in some cases large, were not what is now considered powerful, and the penetration of their shot was not sufficient to pass through a parapet of earth that is now pierced even by light rifled artillery. The conditions, therefore, under which artillery was worked, and the means provided for protection against its fire, remained much the same as they were in the time of Vauban. Several events during the Crimean campaign confirmed an impression that has always been more or less entertained—that an increase in the power of individual guns produced greater results than could be obtained by a much greater weight of metal, distributed among a larger number of small pieces of artillery. It is not too much to say that the development of this art has, since 1855, changed the character of war both on land and water. It has established completely the superiority of a few large pieces over a much greater weight of metal in smaller guns. It has given artillery of all classes a range, penetration, and an accuracy of *Fire*, which throw into the shade the greatest results that had been previously obtained. It has also stimulated the advocates of cast-iron smooth bores to produce guns that might rival the rifled artillery; and yet it is by no means probable that the limit of power, either of large smooth-bores or rifled guns, has been arrived at. When it became apparent that mighty results were to be obtained from improved artillery, a great deal of engineering talent was directed to the subject. Comparatively new appliances, such as the steam-hammer, and new methods of working steel, were called to aid in the construction of the new and powerful guns. So much interest, indeed, was taken in the subject, and so much attention absorbed by it, that the conditions which these improvements in artillery themselves imported with them ran some danger of being neglected. The power of artillery became so great that the ordinary provisions for protection against its fire were rendered useless. Forts that were considered strong twenty years ago would crumble under the shock of modern projectiles, and in some cases would be even too weak to support the guns while they were fired. That service which the new artillery affected most palpable was the Navy, and the Navy accordingly took the initiative in introducing means calculated to resist the penetration of the new and terrible projectiles. Every one is more or less conversant with the process that has been going on of covering ships' sides with iron, which has increased in thickness till it really looks as if the process at last would only be limited by a ship's power of flotation. Warships, however, not only protect their sides against shot, but they also carry the heaviest artillery on their decks. This fact could not be overlooked by those who had to construct coast defenses, as well as other works against which modern heavy artillery might be used.

I shall not enter into details regarding the successive steps which were taken in England in this direction, as I understand Colonel Jervoise has already done so in this Institution. It is enough to state that great engineering skill has been exercised, and unwearied efforts have been made to meet the new conditions. That skill and these efforts have, with the experiments at Shoeburyness, given us defensive iron structures which are marvels of strength and ingenuity. Unfortunately they are also marvels of costliness; and there is room to hope that their use will therefore be generally confined to such positions on *land* as can only be protected by such iron structures. This hope is founded on another system, with which my name is connected, and which I am here to explain. Before doing so I shall point out the dilemma which left military engineers no alternative, and which compelled them to give up in succession the use of earth, concrete, granite, etc., and at last to resort to the most expensive, but the strongest, material—*iron.*

There are two considerations always to be taken into account in providing the means of using artillery: the one is to place the gun so as to be most formidable to the enemy, and the other is to place it at the same time under as much cover as possible, so that it is not liable to be disabled, nor are the men serving it liable to be destroyed by hostile fire. These two conditions interfere with one another; that is to say, whatever has hitherto been gained in one direction has been lost in the other. Guns, *en barbette*, lack protection; guns in embrasures or in casemates sacrifice, on the other hand, free lateral range, and it is more difficult in their case to see the enemy, and therefore to lay the guns in action. The difficulty that presented itself with the introduction of late improvements in artillery was simply that the increased precision and range, coupled with great improvements in the manufacture of large shells and also in small arms, rendered barbette batteries too exposed to be relied on. At the same time the tremendous penetration and precision of the new artillery rendered the ordinary parapet and embrasures useless. What was to be done under these circumstances? Protection from direct fire must be got at any price. The first impulse would be to thicken the parapet. This could not, however, be done, as the necessary angle in the cheeks of the embrasures required for training the guns opens up a wider aperture, in direct proportion to the thickness of the parapet, making the *maximum* thickness in practice 30 ft. But shot have been known to penetrate more than 30 ft. into the earth; and the most important part of the parapet, viz: that near the guns, must always be thin and weak, whatever may be the thickness of the rest. Shells, striking this part, would just meet sufficient resistance to burst them, and would make havoc among the men. Next, granite masonry was thought of; but it proved in some respects worse than earth, and was found practically bad; there was no alternative but to go to iron. This conclusion was reluctantly arrived at, and reluctantly it was acted on.

The decisions of committees which investigated all the bearings of the question, the opinions of professional men and the experiences of the American war, all coincided, and accordingly our important coast-works were designed to receive *iron* shields, casemates and cupolas. Vital positions in England, such as dockyards and arsenals, must be fortified. It would be false economy, indeed, to use any method of fortification that experience has proved to be insufficient. *No savings* could justify the erection of works that might prove at once the tomb of their defenders and perhaps of the nation's honor. Therefore the only proper decision was to take that means to meet the difficulty which was at the time considered best and safest. Expense was properly a consideration very secondary in importance to efficiency.

I shall now endeavor to point out the difficulty of the task which lay before the engineer, even after the decision in favor of iron, from the extraordinary advances, already spoken of, in artillery. There is only one morsel of comfort left for those who have to provide for the requirements of defense, viz: that a form of artillery fire of a very galling nature remains exactly as before, and indeed is not much better, than it was in the time of Queen Elizabeth. What is alluded to is vertical or mortar fire. There is some consolation, too, in the reflection that the cause of this fire not being much improved is one to a great extent likely to be lasting. Rifled mortars would no doubt lessen deflection to right or left; but as long as gunpowder is affected in strength by the slightest atmospheric or other influence, and still more certainly as long as a slight error in elevation at long ranges will make a large error on the plane of fire, the comparative inaccuracy of vertical fire must continue. To show how little can be done in this way compared with the admirable precision and accuracy of direct fire, I may state that 100 rounds were fired one day last season at Shoeburyness at 800 yards range, with a 13-in. mortar, at the row of experimental casemates, which cover a good deal of ground. The mortar was laid with spirit-levels and all the appliances of the school of gunnery, and yet the 100 rounds were expended without a single hit. If such is the case with a steady platform and under such exceptionably favorable circumstances, it can easily be seen how uncertain in its effects would practice be from mortar-boats, which move with every wave, if directed at an equally small object. During the eleven months' siege of Sebastopol the French had 242 mortars engaged, which were themselves exposed to vertical fire, and yet not one of these mortars was disabled. It is indeed a strange contrast—that while direct fire is getting more powerful, more accurate and more destructive every year, vertical fire remains much as it was, and can only be relied on to hit a large object, such as a fort, a town, or anything that covers a good deal of ground. Notwithstanding this, it would be a great mistake to despise it as a powerful and galling means of attack.

To return to the difficulties of meeting direct fire in coast defense. It must be borne in mind that the batteries intended to engage ships are obliged to meet an enemy who can move his position to that quarter where he is least exposed, who can continue in motion while he is conducting his attack, and who can seek out the most vulnerable face of the land-work to operate upon. In constructing such batteries it is first of all necessary to make them of sufficient strength to resist the guns of ships which are the most powerful that can be made. It is next required that these batteries should be constructed in such a manner that they can direct their fire with rapidity and precision in any direction in which the ships can take up their position. And lastly, it is required that they should mount guns of sufficient weight and power to be formidable to the heaviest iron-clads.

In former times guns *en barbette* were preferred for this purpose, because they met the two first requirements alluded to; that is to say, that from not being confined by embrasures or ports, they were able freely to follow their floating enemy, whatever position he might take up; naval fire at that time being neither so correct nor so formidable as to make such batteries unserviceable. The case, however, is now completely changed; for not only have guns been improved, but ammunition also, and heavy shells are most destructive. Rear-Admiral Porter, of the United States Navy, in a report on coast defenses, says: "Such guns, *standing so high up*, are just the objects that naval gunners would delight to explode their shrapnel against, and, from my experience in naval gunnery, the third shell would kill every man at the gun." Von Scheliha, in his treatise on coast defenses, "Guns mounted *en barbette* may always be silenced by an iron-clad." This form of battery, therefore, is disposed of. We shall now examine the difficulties connected with the other alternatives. Common masonry batteries have been condemned as worse than useless, as they would only make the ship's fire more destructive than if directed against guns *en barbette.*

Next comes the expensive alternative which has been adopted, viz: iron shields, casemates and turrets. It is most interesting to examine how far this system of iron, the last alternative left, meets the three requirements of coast defense alluded to, and to see what very great difficulties had to be encountered in applying it.

The three requirements are thus recapitulated:—1st. Strength of the battery to resist naval fire, and give sufficient protection to the men. 2d. Power of figthing the guns with accuracy and effect, of following the enemy with ease as he moves, of being able to face him on any side from which he approaches. 3d. Power of using the most formidable guns to advantage.

The first difficulty was to decide the matter of strength. Now guns are becoming more and more weighty and powerful every day, and therefore the strength required to resist them is an unknown quantity. An iron casemate of the present proposed strength costs, according to official returns, with all the battery adjuncts except the gun and carriage, about £5,000 or £6,000 for each gun. A 2-gun turret, about £25,000 or £30,000.* If guns of 50 tons are introduced in ships, as is proposed, these defenses are at once quite inefficient, and it is not known how strong or how expensive should be the iron works to replace them. Such questions must be very embarrassing indeed to those who have to decide these matters. Besides protecting the gun and carriage from the enemy's shot, protection must also be given to the men. This is the most serious of all considerations in coast defense, for the following reasons: The best experience we have regarding naval attacks on land-works is derived from the late American war, in which a great many actions of that kind took place. It would be unwise to ignore this experience, because the increasing power of artillery only gives it more weight. During the whole of that war very few guns were destroyed by the naval fire in earthen batteries. At Fort Wagner, only three guns were totally dismounted, although 2,864 shot and shell were fired into it in 48 hours, and the bomb-proofs were hit 1,200 times. Seventeen siege mortars, several cohorns and thirteen heavy pieces of artillery were incessantly employed. At Fort Fisher the bombardment was opened at the rate of 115 shells per minute, and although the guns were mounted *en barbette*, only two of them were dismounted when the place fell. At Fort Powell a tremendous bombardment from mortar and gunboats (the most accurate firing being from 15-in. mortars) was maintained from 22d of February till 2d of March, and not a single gun was dismounted. The success of the ships over the forts was gained by demolishing the works, and still oftener by making the service of the guns so dangerous that the men could not work them.

Rear-Admiral Porter, U. S. Navy, in his report on coast defense, states: "The new fashioned casemates turned out to be no better than the guns *en barbette.* They were perfect slaughter-houses, and were piled up with dead and wounded. Every shell that went through the port-holes killed and wounded every man in the close casemate. This proved to me most satisfactorily that guns in casemates were no better protected from shells than those *en barbette.*"

With such evidence as this before them, from men who were conversant with all the events of that great war, it was indeed a serious question to decide what was to be done. I myself cannot see how men in an iron casemate are as much exposed as in a barbette battery; but there is no doubt that if the port of the strongest casemate was as large as those referred to by Admiral Porter, it would be open in the same circumstances to the same dangers, as the damage was done by entrance of shell through the port. The protection a casemate would afford from vertical fire in such a case would be but a poor advantage if more correct and more deadly weapons than the mediæval mortar could still search out at times the

* The price of a permanent Moncrieff battery, with magazines, etc., including the extra expense of carriages, is from £1,100 to £1,500 for each gun; an iron shield battery, from £1,800 to £2,000 per gun; an iron casemate battery, from £5,000 to £6,000 per gun; a turret, from £12,000 to £15,000 per gun.

exposed point of a casemate and kill every man inside. The next requirements in a coast battery, viz: to be able to follow an enemy amidst clouds of smoke, and to lay the guns on him with precision and dispatch, formed a more embarrassing difficulty still. On the one hand, the ports must be constructed for muzzle-pivoters to give protection. On the other hand, if they are made so small it is difficult to see through them, to fire correctly and quickly at different elevations and on different sides on a moving enemy. The battery is in the position of a knight, who must either expose his vitals to his enemy's lance or put on an armor that paralyzes his sword arm. There is as much protection in the power of being able to strike as there is in being able to guard. As naval actions are likely to be short and decisive, it must have appeared extremely doubtful whether it was worth purchasing increased safety at the expense of losing the attacking power. The last of the three requirements in coast defense stated was the necessity of using the most powerful canon. This did not present the same difficulty as the other two, because the designers of our defenses had been presented by my friend Captain Coles with the means of mounting the heaviest guns to fire in any required direction. When very large and valuable guns are used, it is not advisable to cramp their action and restrict it to a small area. The turret was therefore preferred to the casemate when lateral range was required; and though apparently very expensive, it was in reality cheaper than casemates, because, although the mounting of guns in this manner cost more, they were enabled to do much more work, and there was thus an economy both of guns and men.

Having thus far endeavored to describe the extraordinary difficulties which the new improvements in artillery inevitably entailed on the engineers, I shall now direct your attention for a short time to the difficulties in which the same improvements involved the artillerymen themselves. These difficulties, though not quite so important as the engineering ones, were very serious indeed, and had not yet been quite overcome. They consisted chiefly in the difficulty of making carriages and platforms strong enough for the new and powerful rifled guns. These pieces burnt enormous charges of powder, and hurled bolts as heavy as an old field piece at 1,000 ft. a second. The recoil of such guns represents a violence of force the like of which man has never had to deal with before. Imaging 12, 18, or 25 tons of compact iron started in an instant into rapid motion with a violence that mocks the blow of a steam-hammer. This force has to be controlled and restrained. It is no wonder then that, when met directly and stopped by friction, as is now done in the ordinary system, the difficulties are enormous. The horizontal strain on the platforms, pivots and racers, is so great that it has not yet been quite successfully met; constant changes and inventions are being made to render this force more harmless.

I hope I have now conveyed to your minds some idea of the embarrassment and difficulties which have fallen upon both the artillery and engineers by the rapid improvement of these formidable engines of war, and of the persistent, able struggle which both have maintained to meet directly the terrible forces with which they have to contend. They have both succeeded to a wonderful extent, but their success is blighted by that curse of the science they practice—the law that up to this time has existed—viz: that what was gained in protection was lost in efficiency, and the converse. Happily, I had the good fortune to conceive and develop an idea which abrogates this law. The very force, the existence of which has been so great a difficulty in the artilley question, has been compelled to perform a service that at once sweeps out of existence a great many of those other difficulties that embarrassed fortification. When two evils co-exist, it is sometimes good policy to make them destroy each other.

I shall now refer shortly to the train of ideas that led me to think of solving this important problem in quite a different manner from that in which it had been attempted, which had led to the adoption of a most expensive class of works. My solution gives a system capable of mounting the heaviest artillery, while it simplifies the vexed question of fortification. It gives protection without the expense of using iron, and free lateral range to the guns without exposure. The system is indeed a simple one; it does not require either brute strength or heavy expenditure for its application; nor does it need mighty forges to weld iron walls to protect our guns and gunners; it only calls to our aid the simplest and most docile forces of nature. Instead of trying to meet force by force, I make my guns bow to the inevitable conditions which science has imposed; and instead of wasting energy, money and skill in attempts to raise a buttress against the new artillery, I employ the hitherto destructive force of recoil to lower the gun below the natural surface of the ground, where it can be loaded and worked in security and in comfort; and at the same time, I have made that destructive force so much my servant that I compel it at my pleasure to raise the gun again into the fighting position whenever it is required. In 1855, while watching the interesting operations before Sebastopol, and endeavoring, as well as I could, to understand the conditions under which the siege artillery was used, I conceived the idea which is now realized. It was then that I saw the value of earth and the importance of simple expedients. It was plain that the weak point of a battery was the embrasure, which formed a mark to fire at, an opening to admit the enemy's shot, and required constant repair even from the effects of its own gun, which in firing injured the revetments of the cheeks. I also came to the conclusion in my own mind that a remedy for some of these defects could be devised. Afterwards I worked at various plans, of which sketches were made, or models; but each design had defects which discovered themselves to me as my experience increased. The real difficulty of the thing arose from the necessity of providing for the enormous strain of the recoil. These early designs, which were sometimes excellent in other respects, broke down at this difficulty, and although some of them no doubt would answer with small guns, they were not calculated to meet the tremendous recoil of large rifled pieces.

At last I hit on a simple principle that would meet this difficulty to advantage—the interposition of a moving fulcrum between the gun and platform. Then I knew that the problem could be solved; and feeling the great importance of the subject, I resolved to devote my efforts to working it out completely. While directing my attention to this simple and then apparently obscure matter, I was, as you may imagine, neither an idle nor disinterested watcher of the progress of artillery. Every step in advance was riveting the certainty in my mind that the system would one day be required, and with this conviction I refused to allow either discouragement or delay to make me desist. I shall now endeavor to explain shortly the system which bears my name, as far as it relates to coast defense.

It consists of three parts: 1st. The mechanical principle of the gun carriages. 2d. The form internal and external of the batteries. 3d. The selection of ground for placing the batteries, and the arrangement for working them to the greatest effect; or, in other words, the *tactics* of defense for positions where the system is employed. The principle on which the carriage is constructed is the first and most important part of the new system, because on it depends the possibility of applying the other parts. This principle may be shortly stated as that of utilizing the force of the recoil in order to lower the whole gun below the level of the crest of the parapet, so that it can be loaded out of sight and out of exposure, while retaining enough of the force above referred to bring the gun up again into the firing or fighting position. This principle belongs to all the carriages; but the forms of these carriages, as well as the method in which this principle is applied, vary in each case. For instance, in siege-guns, where weight is an element of importance, the recoil is not met by counterpoise. With heavy garrison guns, on the other hand, which when once mounted remain permanent in their positions, there is no objection to weight. In that case, therefore, the force of gravity is used to stop the recoil, because it is a force always the same, easily managed and not likely to go wrong; and as these carriages are employed for the most powerful guns, it is a great advantage to have the most simple means of working them.

It has been already mentioned that the principal difficulty arose from the enormous and hitherto destructive force of the recoil of powerful guns; and here I shall point out the manner in which that difficulty is overcome. That part of the carriage which is called the elevator may be spoken of and treated as a lever; this lever has the gun-carriage axle at the end of the power-arm, and the center of gravity of the counter weight at the end of the weight-arm, there being between them a moving fulcrum. When the gun is in firing position, the fulcrum on which this lever rests is almost coincident with the center of gravity of the counter-weight, and when the gun is fired the elevators roll on the platform, and consequently the fulcrum, or point of support, travels away from the end of the weight-arm towards the end of the power-arm; or in other words, it passes from the counterweight towards the gun. Notice the important result of this arrangement. When the gun is fired its axle passes backwards on the upper or flat part of a cycloid. It is free to recoil, and no strain is put upon any part of the structure, because the counter-weight commences its motion at a very low velocity. As the recoil goes on, however, the case changes completely, for the moving fulcrum travels towards the gun, making the weight-arm longer and longer every inch it travels. Thus the resistance to the recoil, least at first, goes on in an increasing progression as the gun descends, and at the end of the recoil it is seized by a self-acting pawl or clutch. The recoil takes place without any jar, without any sudden strain, and its force is retained under the control of the detachment to bring up the gun to the firing position at any moment they may choose to release it. The recoil, moreover, however violent at first, does not put injurious horizontal strain on the platform. In my experiments at Edinburgh with a 32-pounder, I found that so slight was the vibration on the platform caused by firing that the common rails on which the elevators rolled in that experiment, and which were only secured in the slightest manner, did not move from their position, nor even when heavy charges or double shot were used, did sand and dust fall off their curved tops.

At a still earlier experiment made with a model of a 95-cwt. gun, the model was fired on the ice with excessive charges, and nevertheless remained stationary. This valuable concomitant of the system cannot be appreciated fully without referring to the difficulties that have been experienced, and are now felt, in getting pivots, platforms, etc., on the ordinary system, strong enough to mount the new artillery, where the recoil is stopped by friction applied directly by means of what are technically called *compressors* attached to the platform.

I shall not detain you by detailing these circumstances, but will only state that the first two 12-ton guns on ordinary carriages that were fired in casemates were both *hors de combat* the first shot. The accident referred to was serious, because it might occur in action, and in that event would disable the gun, *pro tempore*, as completely as if it had been dismounted by a shot. Some credit may be claimed for the new system, on the ground that it provided a carriage for a heavy piece of artillery on an entirely new principle, in which not a single part was copied from anything that had been formerly used, dealing with new conditions and performing the functions that no other carriage had done, and yet this new carriage (the first complete one of its kind) has now fired *two hundred rounds*. This practice has been carried on with only a few accidents which pointed to defects in the gearing, which were easily remedied. By treating this violent force in the manner above described, a good deal of the strength that is required in other systems becomes unnecessary. It will be observed that the interior slope of the parapet gives the most complete protection to the men, especially when the dome form is adopted.

Up to the present time the new system has only been considered as an improvement, and its value has only been estimated as an adaptation to existing forts, and there are no proposals for applying it *per se*. I am extremely anxious to impress on you and on my countrymen that its full value cannot be seen in this manner, and that it suffers injustice by being thus treated. I trust its proper use will be fully discovered before the inevitable lesson is dictated by war, and that it will be applied in works expressly designed for it, and not merely adapted to its use.

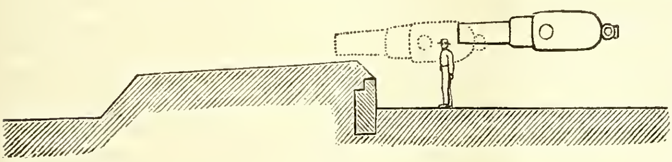
The third part of this system consists in its application to given positions and disposition of the batteries, and methods of working them in concert with and in support of each other. If I might be excused for using the paradox, this system of coast defense consists in the absence of any defined system; that is to say, instead of making large regular forts, and forcing surrounding circumstances into harmony with them, every accident of the ground in this case will be seized, where available, and small batteries, consisting of a few guns or of one powerful gun, laid down so as not to take away the natural aspect of the position. These batteries would be well retired from the channel, and placed so as to support each other in case of attack, and should, when circumstances permit, afford flank defense to each other, in conjunction with obstacles to the approach of the enemy. In connection with these gun carriages are some improvements of minor importance, such as trunnion pointers, reflecting sights, graduated races, and so on, which it would be out of place to discuss at present, but which contribute to the efficiency and completeness of the system, and are more or less required for carrying it out as a consisent whole for coast defense.

The second part of the system, viz: the profile of the batteries, is of the highest importance, because unless it is attended to great advantages are lost. This, unfortunately, makes the system extremly difficult of adaptation to existing works. In order to get the full advantage of it, no exterior slope of parapet should be exposed to the view of the enemy. This prevents him from being able to tell whether the fire be correct or wasted, and affords no means to him of correcting error. The battery, in fact, is masked; so that at some distance away, a moving ship would have considerable difficulty in laying her guns on one battery, and still more difficulty if there were several batteries judiciously placed for the purpose of deceiving the eye. It can easily be understood that the slighest error in elevation would either carry the shot harmlessly over the battery, or else cause it to ricochet off the glacis or superior slope. In fact, when the gun is down the enemy has nothing to aim at but an undefined horizontal line.

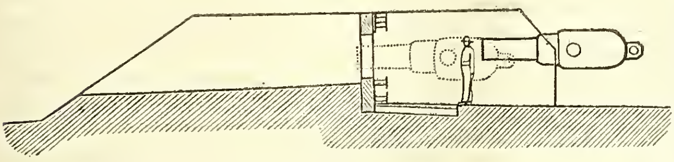
It is proposed to employ the Moncrieff batteries in connection with strongholds for infantry and light artillery, commanding, if possible, the sea batteries, so as to make them untenable by an enemy, and so placed as to be in the best position for a reserve, ready to support any point attacked; the whole connected with good and sheltered roads. In stopping the passage of a navigable river or channel, for instance, the guns, instead of being massed, would be scattered round the points where marine obstructions were placed. These guns would be disposed in such a manner as to retain as much as possible for the defense the advantages of a free lateral range, converging fire and different amounts of command. In other words, the method consists in placing in position the heaviest and most powerful artillery to the greatest advantage, making that the first consideration, and afterwards protecting the batteries, by separate and distinct arrangements easily devised by officers on the spot, against assault by any force that ships might land for that purpose When an object is to be obtained, I prefer to grapple with the most difficult and important part of it first, do that well, and meet the other requirements afterwards, with as little loss of efficiency as possible.

Sketch showing in section specimens of five methods of mounting heavy Coast Artillery.

BARBETTE.

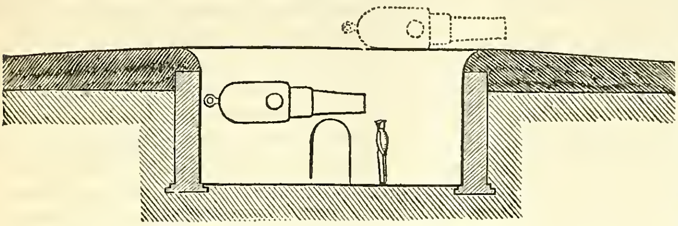


SHIELD.

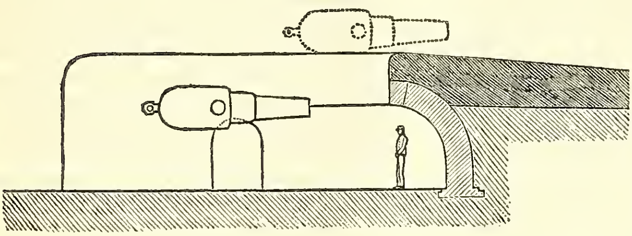


The first object of coast defense is to meet and defeat the attack of powerful ships; the next is to protect the shore batteries against landing parties. It must not, however, be forgotten that there are positions of such importance that they might be attacked by an army on land. Such positions must either be defended by another army placed in a favorable position by such arrangements as those above referred to, or else by regular and complete earthworks thrown up in time of danger, which would enable a still smaller garrison to resist anything but regular approaches. There are, however, few coast positions of such importance as to

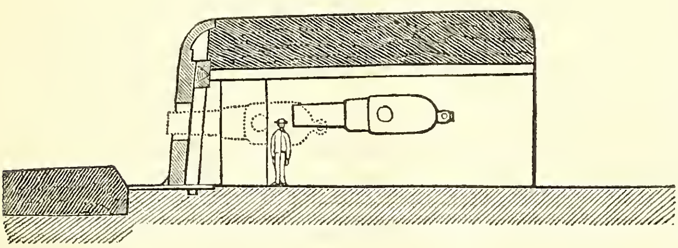
Moncrieff.



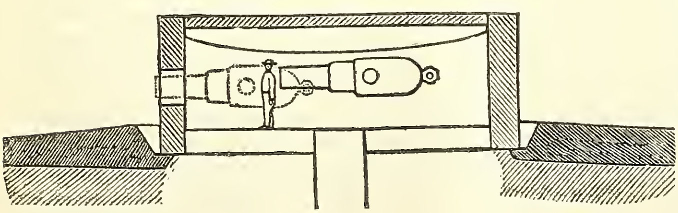
Moncrieff



Iron Casemate.



Iron Turret.



draw the attack of a whole army; and such positions, as a rule, are now provided with regular works of a very high order; whereas there are many positions exposed to a naval attack, such as our large mercantile ports, etc.—They are almost invariably centers of population, which require only field-works and good small arms (which are now more powerful than ever) to repel the most determined attacks of any numbers that war ships could land. I believe many of the *present* coast works are defensible only against a *coup de main.* Wherever land attack is of more importance than naval, the character and efficiency of sea batteries must give precedence to those considerations which provide against assault. On the best provisions for meeting this I do not pretend to give an opinion. In such cases, the possibility of attack by both direct and vertical fire must be kept in view. Where my system is employed for arming such works, one or two precautions would increase the power of resistance. 1st. The large guns for operating against ships, with traverses and *parados* to each, should be kept as far apart as space will admit. 2d. Ample and thoroughly complete bomb-proof cover for the whole garrison should, if possible, be supplied in the middle of the work, with arrangement for interior defense (not barracks, but places for emergency) thoroughly secure from vertical fire—good and healthy barracks for the men being made independent of the works, and by preference kept out of the way. 3d. Howitzers and light artillery ought to be kept in reserve, in bomb-proofs constructed for the purpose, and (with the new system this can easily be done) also with the means of changing these to any required face.

The dispositions of defensive batteries, such as those I have very imperfectly attempted to describe, would not be complete without good arrangements for internal communications, not only by roads, but by telegraph, with a clearly laid down and simple method of working them; that is, not liable easily to go wrong nor to lead to mistakes, and which would not require very high skill. Such arrangements would increase the power of the defense, and indeed would be necessary with the detached system. I have accordingly given them some attention, and designed a general plan of laying off the ranges and working the telegraphs, which will make it possible to supply simultaneous information. The system I refer to (which has been submitted to the Director-General of Ordnance) would apply to any position, but its particular application would vary in each case. It is extremely simple. One part of it depends on electrical instruments which I have invented for the purpose, and which, without either calculations or experience, give the range and positions of an indicated ship at every gun in the position.

Another part of it enables the officer directing the defense to deliver in one instant, by the touch of his finger, a converging volley from one or both sides of a channel on a vessel sailing past. The possibility of delivering correct fire in this manner on a moving object, without aiming, and by an officer not even in the battery, was illustrated in one of my experiments with the 7-ton gun carriage at Shoeburyness; and I trust I may be given some day a chance of showing to what perfection this system can be carried. Methods of determining the distance of vessels from batteries are practiced here and in some continental countries. My method is designed to be quicker, simpler, and therefore more effective. It is adapted to work in conjunction with the arrangements for sub-marine mines. That part of it which gives the required information for sighting the guns is of so simple a character that the most uneducated gunner cannot make a mistake in its application. There are many other features of the system besides those I have particularly referred to which I shall not now discuss; each requires different treatment. Among these there are methods of mounting guns in ships, floating batteries, Moncrieff carriages for heavy guns of position, adapted for locomotion, for coast defense and for siege carriages.

AMERICAN LOCOMOTIVE BOILERS.—It is impossible for an English engineer to read the records of American boiler explosions without being struck by the very large number of failures of locomotive boilers which occur annually on the other side of the Atlantic. In this respect the American records form a strong contrast to those of explosions in this country. Here the number of locomotive boiler explosions seldom exceeds three or four per annum, and considering the large number of locomotives now at work in the United Kingdom, locomotive boilers may be said to possess a greater immunity from explosion than almost any other class. To a great extent this is, no doubt, due to the fact that locomotive boilers are, almost always, worked under skilled superintendence, and subject to frequent inspection; but it is also due to their being, with but few exceptions, well constructed in the first instance, and properly proportioned for the work they have to perform. In America, locomotive boilers, although under quite as skilled superintendence as our own, are yet more liable to explosion from the fact of their having generally less superfluous strength when new than would be considered necessary by our railway engineers. American locomotive superintendents use $\frac{5}{16}$ in. and $\frac{3}{8}$ in. plates, where we should use $\frac{7}{16}$ in. or $\frac{1}{2}$ in.; and notwithstanding the high pressures used, double riveting is still the exception rather than the rule. The consequence of all this is that in a list, now before us, of 94 boiler explosions which occurred in the United States during 1868, no less than 23 explosions of locomotive boilers are recorded, these explosions thus amounting to over 25 per cent of the whole; while from another record of the explosions which took place in the month of May last, we find that during that month four locomotives exploded on different American lines. These are facts which demand the serious consideration of American locomotive engineers, and we trust that in the records of future years we may find evidence that the lessons which they teach have not been disregarded.—*Engineering*.

STATION ROOFS.—The large number of the members of the Institution of Civil Engineers will recollect the interest with which Mr. J. W. Barry's paper on "The City Terminus Extension of the Charing-cross Railway" was received at one of the meetings in the spring of last year. The paper and the discussion upon it has lately been issued to the members, and its re-appearance, in printed form, will revive, to some extent, the arguments advanced at the time referred to. A certain number of the speakers made common cause against roofs of large span, upon the sole ground of their cost, an objection equally applicable to the dome of St. Paul's, or the grand façade of the *Παρθενος*—the vestal temple of the goddess of Engineering, engineering being understood in its true Minervian sense of wisdom, war, and the liberal arts. Considered as a roof merely, a roof of great span costs more than a series of roofs of smaller span covering the same area. But, taking the roof as a part of a costly building, the difference of cost between a roof 200 or 300 ft. span, and two or three roofs of, respectively, one-half or one-third the span, is relatively small. The weight and cost of the principals alone rise in proportion of the square of the span, being, say, twice as much for a single span of 250 ft. as for two of 125 ft. The roofing or covering is of the same weight and cost, no matter what the span. In station roofs of from 212 ft. to 240 ft. span, the weight of the principals varies from one ton to one and a half tons only per running foot of the length of the building, so that in a roof even 800 ft. long, the saving by making two spans of 120 ft. instead of one of 240 ft. would not amount to more than the saving of from 400 to 600 tons in the principals, with the expense, on the other hand, of say, 150 tons of cast iron in forty intermediate supporting columns. The narrower spans are in any case the cheaper, but the utmost cheapness is not a *sine qua non* in buildings of a monumental character. Few genuine engineers, loving their profession for its own sake, would argue the contrary. Indeed, in the very discussion to which we refer, the arguments to the contrary came from a somewhat unfortunate contractor, and from the engineer of a non-dividend paying railway; an engineer who, having by his writings set up some pretensions to authority upon station construction and station architecture, has nevertheless given to the metropolis one of the ugliest works of its kind of which London has to be ashamed. Although, at present, works of associated private enterprise, railways are really as much public works as are the Government offices themselves, and, as public works, something beyond bare convenience is to be considered in railway-station architecture. The pretense that railway stations are unworthy of architectural treatment—a pretense often advanced—is in itself unworthy of our profession, unworthy of railway enterprise, and unworthy of public taste. And it is out of the question that a series of low, narrow-span sheds, such as might be run up for a manufactory or a warehouse, can be considered as an architectural work. In stations of which the total cost, apart from land and compensation, is from £150,000 to £230,000, and where architectural effect is almost incumbent upon the engineer, the difference of from £3,000 to £4,000 in the cost of the roof, representing an interest charge of from £150 to £200 per annum, is not a subject for very grave discussion. Where from five to ten million passengers pass through such a station yearly, the cost to each passenger, at each journey, is but from, say, the $\frac{1}{150}$th to the $\frac{1}{200}$th part of a penny, or a penny for every 150 to 200 journeys, short or long, say a penny every three months for the season ticket holder entering and leaving the station daily six times a week. A daily traffic of from 20,000 to 40,000 passengers, half in each direction, is nothing very remarkable "in and out" of a great Metropolitan station. The cheese-paring engineers, of whom there are a good number, may, possibly, in view of such easily established facts, condescend to admit that considerations of grandeur and general effect, attended also with greater convenience, comfort and safety, should be allowed to have some weight in station design.—*Engineering.*

TURBINE TESTS.—Frequent inquiries are made for full and trustworthy data regarding the economy of turbine wheels, especially the new wheels so vigorously advocated of late. Some of these have merit we believe, but the public require better proof than interested statements. A commission of engineers, whose ability and character are above suspicion, should be asked to undertake tests at the joint expense of the wheel makers. Such a trial would be exhaustive and convincing, and moreover it would greatly stimulate the turbine wheel trade.

SEWAGE CARRIED BY WATER.

From "The Artizan."

The transporting power of water, when conveying sewage, is becoming a subject of very great importance, as both the fertility of the soil and the sanitary state of our large cities are affected by it. It is now pretty generally admitted, that plants can best absorb nourishment from the soil when the soil receives the manure in a liquid form; but it also would appear that vegetables do not thrive so well when the water is very highly loaded with sewage.

There would, therefore, seem to be some certain proportion of water and sewage best adapted for the soil to absorb and again to give it off to the plants; and possibly this very proportion is also the best when water is the medium by which the sewage is transported, while at the same time it may be found that a city requires just this quantity of water to insure proper sanitary measures being carried out.

It is self-evident that the refuse of our cities could not be made to flow without water—be the slope or head of pressure ever so great; and also that pure water will flow with almost an imperceptible slope, but under such circumstances this pure water could not hold in suspension any foreign matter. Again, as it is necessary that sewage should be conveyed under ground for sanitary reasons, and that to utilize this sewage for irrigation it will require, under most circumstances, to be again pumped up, the question is, what is the velocity, in other words, the slope or head of pressure that should be given, which will require the least power to be expended in pumping?

If too little water be used, we must increase the fall, while too much of it involves needless pumping. It is, therefore, quite possible that it may be discovered that the proper liquification of sewage, so as to have the least expenditure in pumping, may be also the very same proportion per head required by our cities for sanitary purposes, as well as the very best proportion for agriculture.

The question, though very complicated, is one of great interest; and its importance is becoming more and more evident. That the soil can, when irrigated by sewage water, absorb the foreign matter, and give it out again in the best possible state for the growth of plants, is admitted, while the water being relieved of this matter, sinks into the ground below in almost a pure state; so this very water, which has been taken from a river high up in its course, can be made to supply our cities; then convey away the refuse, distribute it over the fields, adding to their fertility, and again return to the parent stream through the underground springs in a state to aid rather than injure navigation, for it brings no foreign matter along with it.

According to Beardmore, a bottom velocity of 40 ft. a minute will sweep along coarse sand, and 60 ft. fine gravel, but this is with pure water not already loaded with solid matter. What may be the necessary velocities with various loads of solid matter held in suspension, are questions yet to be determined by experiment. So as water holding sewage matter in suspension must be affected by the load it has to carry, the velocity requisite for sweeping along coarse sand under such circumstances, must be much greater than if only pure water was the disturbing medium.

For the sake of argument, suppose that a mean velocity of 1 ft. per second is the necessary velocity in a closed pipe, the question is, what is the size of pipe required to convey away the sewage of a given number of inhabitants?

Let this number be 100, and that two cubic feet of water (rather over 12 gallons) is the water supply for each man, woman, and child, during the 24 hours.

Now, as eight out of the 24 hours is required for sleep, there remains only 16 hours of the day that the greater portion of the sewage is supplied, and during certain hours of the day there must be a greater discharge than at others; allow one-fourth more to be deducted to admit of the maximum discharge, or in all only 12 hours.

The rate of discharge per second would therefore be

$$\frac{100 \times 2}{12 \times 60 \times 60} = .048 \text{ cubic feet,}$$

or 82.944 cubic inches, which it is supposed requires a mean velocity of a foot a second, that is 12 inches; so $\frac{82.944}{12} = 6.912$ sqr. inches is the sectional area required for a pipe to discharge the sewage for 100 inhabitants; or a three-inch pipe is sufficient to pass off this maximum discharge of sewage of 100 men, women, and children.

Again, suppose that the ground is such that there is *no available fall* along the line this sewage has to be discharged, and the length of pipe is 500 yards, the question is how to obtain the velocity of one foot a second?

Adhering to Beardmore's tables, the discharge being .048 feet a second, or 2.880 ft. a minute, distance 1,500 ft., and diameter of pipe 3 in., there is

$$\frac{1,500}{\left(\frac{73.6}{3}\right)^2} = 2\tfrac{1}{2}$$

That is, with $2\frac{1}{2}$ ft. head of water and a three-inch pipe (which is 500 yards long), in 12 hours this pipe could discharge the sewage of 100 inhabitants, but if the head of water was raised to 10 ft., this same pipe could discharge more than four times as much.

The question is, how is this fall to be obtained on perfectly level ground? and the answer is, by pumping; but it is obvious that *all* the water does not require to be pumped, but only a small portion of it, by simply having all the water-closets in a house above the level of 10 ft.; and whatever water may be used in the kitchen or ground floor only, can be pumped up to the required level, a work that would hardly occupy the kitchen servants above a quarter of an hour daily. There will also be this advantage, that, having to pump up all the dirty water in the sink or cesspool, no bulky matter could find its way *up* the pump, but would have to be removed by hand to the ash-pit, to be carted away in a dry state; thus there could be no danger of the sewage pipes ever being blocked up by solid matter.

Mr. Chadwick, in his report on the Paris Exhibition on dwellings for the working classes, has drawn attention to a number of most important sanitary questions, of which the above is one of them, and at page 76 of this able report points out, that fresh sewage that has not undergone the process of decomposition is not only more valuable in its fructifying power in the proportion of one to three; but, instead of killing fish when it escapes fresh into a river, the fish come and feed on it. So the question is, why is it that there has been so great an outcry about the evil effects of the sewage of our cities?

The reply is, that it is from a want of a proper knowledge of the abrading and transporting power of water, and to prove this, one example will be sufficient. At a well-known watering-place on the west coast of England, the local board of health are at present constructing a culvert to convey away the drainage and sewage of a portion of the town. The land is nearly level, so there is no great outfall that the sewage and drainage can flow off quickly by its own gravity. To provide, therefore, for this want of natural fall, the channel along which the sewage and drainage is to escape is made large, the culverts being 2 ft. by $1\frac{1}{2}$ ft., of egg-shaped section. The houses for which this sewer is being built are twelve in number, containing something rather under 100 inhabitants, and this drain is 500 yards in length, which will cost somewhere about one pound sterling per running yard, which, at five per cent, is an annual tax of rather over £2 a house.

Now the first mistake made in this town, we are of opinion, is combining the storm with the sewage drainage; for the former could, with impunity, be permitted to drain into the sea; but this mistake probably arises from a want of a proper knowledge of the abrading and transporting power of water, for if the storm drainage has already got its proper load of solid matter, where probably the slopes over the surface are much greater than within the culverts, it is evident that the highly charged storm water cannot aid in scouring out any prior deposit, but will rather add to it. Consequently, the admission of this storm drainage rather tends to block up the culvert sewers instead of keeping them clear, so there can be nothing gained by having large sewers to convey away the storm drainage also.

It has been said that the sewer now being built has a section of 2 ft. by $1\frac{1}{2}$ ft., but taking the nearest size to this, 2 ft. by $1\frac{1}{4}$ ft., given in Beardmore's tables, where there is a fall of 2 ft. in the mile, with a depth of 12 in. of water in the culvert, we only get a velocity of 59.9 ft. a minute, or what we started with, as required to move along sand by sewage water; but we also find that to give this depth of water, the discharge requires to be no less than 52 ft. a minute, or eighteen times more than the sewage of one hundred inhabitants, while with any decreased velocity it is supposed sand cannot be transported. The natural consequence is, therefore, that the sewer must get filled up, till it has reduced the opening to such an area that the velocity acquired by having to pass through such a small opening, can enable the water to sweep along sand, or, in other words, the culvert sewer gets filled up with decomposed putrid sewage, that poisons the air, earth, and water, while for some one-tenth of the cost probably, a proper system of sewage pipes could be laid down, so that even a new set of pipes could be laid down every other year at no greater cost than the interest on capital laid out on the culvert sewer.

By this head of pressure system also, it is evident that for irrigation purposes there would be little trouble in spreading the sewage over the lands, while by the increased velocity the land would receive it in a fresh state, and thus the greatest benefits to the soil would be secured without any deteriorating effect on the health of the inhabitants, and all at what cost? Merely that the kitchen servants, for a quarter of an hour or so daily, would have to pump up the water in the cesspool to a higher level of some ten feet or so above the sewage-pipe outfall, and thus all these ingenious methods of separating all sorts of rubbish would not be necessary, for they could not be pumped up from the sink, so that only paper in a state of pulp could pass down the pipes. The servants might at first object, but not where sewage arrangements are introduced for the first time, and once the advantage of this system were proved, all objections would soon disappear.

THE ALLOYS OF ALUMINUM WITH COPPER.

From the "American Horological Journal."

When Sir Humphrey Davy announced the fact that soda, lime, potash, magnesia, and the other alkalies were but oxides of a metallic base, it would have been deemed chimerical to have supposed that the discoveries he made by the expensive aid of the battery would at later date become of really commercial value. He did obtain both sodium and potassium in the metallic state. The substances in this form were new to the chemical world, still more strange to the popular. So new was it to the chemists that, on a globule of the reduced sodium being presented to a very distinguished chemist, he, with some enthusiasm, examined it; and, admitting the fact of its being a metal, exclaimed, "how heavy it is!"—when the real fact was that its specific gravity was less than water; the expression was the result of the general pre-conceived opinion that a high specific gravity was a test of a metallic body. It was reserved for a French chemist, Henry St. Claire Deville, to utilize the metal sodium, and that, too, in such a manner that the demand aroused attention to its production;—demand will inevitably bring a supply.

The original reduction was made by Davy by means of the voltaic battery. After it had been proved that these bases were really metals capable of reduction, chemistry brought all its resources to bear on the problem, and they were produced by other methods than the battery. All the processes adopted, however, were too expensive and laborious, involving an extraordinary amount of complicated manipulations with but inadequate results. The metal sodium, which is the immediate subject of our inquiry, long remained an object simply of curiosity or experiment in the laboratory.

The methods of reducing the metal have of late years been so simplified that, to quote Prof. Chas. A. Joy, in the "Journal of Applied Chemistry": "A few years ago a pound of this metal could not have been purchased for two hundred dollars, and even at that price there were few manufacturers hardy enough to take the order. At the present time it can be readily manufactured for seventy-five cents, if not for fifty cents a pound; and the probabilities are that we shall soon be able to obtain it for one-quarter of a dollar."

Deville found that by the reaction of the metallic sodium on common chloride of aluminum, a reduction was effected; the chlorine taking up the sodium, forming chloride of sodium (common salt), while the aluminum was left free in the metallic state. It is hardly necessary to go into the particulars of the process; but a metal well known to exist, had, for the first time, been brought to the world in such a condition of structure that its qualities could be tested, not only chemically, but mechanically. This was the direct result of Deville's metallurgic process of obtaining the reducing agent—sodium.

Aluminum in itself would be of but little use, so that a brief description will be all that is necessary. It is about the color of silver, but susceptible of a higher polish, especially on a fresh-cut surface; it is much less susceptible of oxidation than silver; its specific gravity is but little more than pine wood, and its tenacity, ductility, and laminating qualities are nearly equal to silver. Its use in the mechanical arts is limited, notwithstanding all these qualities, from the fact of its low point of fusibility, and at the heat of the fusible point being easily oxidized, so much so as to prevent soldering, except by an autogenous process. But aluminum does possess a property peculiar to itself—that of forming a purely and strictly *chemical alloy* with copper. It unites with it in any proportion; the compound formed by the addition of 10 per cent of aluminum to 90 per cent of copper has been found to possess all the properties of an entirely new metal, with qualities that render it a very valuable material in all fine work, such as astronomical instruments; and very fine machinery, such as watch-lathes, etc.

The French reports on the alloy are somewhat voluminous, but we give the following :

The color of this bronze so closely resembles that of 18 carat gold, such as is used for the best jewelry and watch-cases, that it is capable of receiving the highest polish, and is far superior in beauty to any gilding.

Samples taken from different parts of the largest castings, when analyzed, show the most complete uniformity of composition, provided only that the two metals have originally been properly mixed while in a state of fusion. These experiments have been made upon cylinders weighing many hundreds of pounds, and are entirely conclusive.

This valuable quality is not found in any of the more ordinary alloys of copper. The alloy of copper with tin, for example, known as *gun-metal*, is notoriously subject to a phenomenon known as *liquation;* in consequence of which a great difference is found in the composition of the same casting, both in the top as compared with the bottom, and in the center as compared with the circumference.

This phenomenon often causes great inconvenience, as the different parts of large objects will, in consequence, vary greatly in hardness as well as in strength. In casting artillery the difficulty becomes a serious one, and no means have yet been discovered by which it can be entirely removed.

This homogeneousness of aluminum bronze is a natural consequence of the great affinity existing between the two metals of which it is composed; and that there is such an affinity is clearly proved by the phenomenon attending the manufacture of the alloy. The copper is first melted in a crucible, and the aluminum is then added to it *in ingots*. At first there is, of course, a reduction of temperature, because the aluminum in melting absorbs the heat from the melted copper; and this absorption is so great, in consequence of the great capacity for heat of aluminum, that a part of the copper may even become solid. But let the mixture be stirred a moment with an iron bar, and the two metals immediately unite; and in an instant, although the crucible may have been removed from the furnace, the temperature of the metals rises to incandescence, while the mass becomes as fluid as water.

This enormous disengagement of heat, not seen in the preparation of any other ordinary alloy, indicates, not a simple mixture, but a real chemical combination of the two metals. The ten per cent bronze may therefore be properly compared to a salt, the more so as it is found by calculation to contain, within a very minute fraction, four equivalents of copper to one equivalent of aluminum.

The ten per cent bronze may be forged cold, and becomes extremely dense under the action of the hammer. The blades of dessert-knives are thus treated in order to give them the requisite hardness and elasticity. But it has another valuable quality which is found in no other kind of brass or bronze. It may be forged hot as well as, if not better than the very best iron. It thus becomes harder and more rigid, and its fracture shows a grain similar to that of cast steel. On account of the hardness of the aluminum bronze, rolling it into sheets would be a tedious and expensive process, were it not for this property of being malleable at a red heat. But it may in this manner be rolled into sheets of any thickness, or drawn into wire of any size. It may also be drawn into tubes of any dimension.

From several experiments, made at different times at Paris, it appears that the breaking weight of the cast bronze varies from 65 to 70 kilogrammes the square millimeter. The same bronze drawn into wire supported a weight of 90 kilogrammes the square millimeter. The iron used for suspension bridges, tested in the same manner, did not show an average of more than 30 kilogrammes. Some experiments were also made by Mr. Anderson, at the Royal Arsenal at Woolwich, in England, who tested at the same time the aluminum bronze, the brass used for artillery, and commonly called *gun-metal*, and the cast steel made by Krupp in Prussia. Taking for the maximum strength of the bronze the lowest of the numbers found, as above, we are thus enabled to form the following table of comparative tenacities :

Aluminum bronze, 10 per cent......	65
Krupp's cast steel................	53
Refined iron......................	30
Brass for cannon..................	28

The comparative toughness of these same four metals was also tested in the following manner: A bar of each was prepared of the same size, and each bar was then notched with a chisel to precisely the same depth. The bars were broken separately, upon an anvil, by blows from a hammer. The last three metals in the table broke each at the first blow, with a clean and square fracture. The aluminum bronze only began to crack at the eighth blow, and required a number of additional blows before the two pieces were entirely separated. And the irregular, torn surface of the fracture showed the peculiarly tough and fibrous nature of the metal.

The elasticity of the aluminum bronze was tested by M. Tresca, Professor at the *Conservatoire des Arts et Métiers*. The experiment was made upon a bar of simple cast metal, and the following is his report: "The co-efficient of elasticity of the aluminum bronze, the cast metal, is half that of the best wrought-iron. This co-efficient is double that of brass and four times that of gun-metal, under the same conditions."

The specific gravity is 7.7, about the same as iron. Another very valuable quality is presented in the fact that it is acted on by atmospheric influences less than are silver, brass or bronze. This places it in the same rank with gold, platinum and aluminum.

Very stiff and very elastic, tougher than iron, very little acted upon chemically, and in certain cases not at all, capable of being cast like ordinary bronze or brass, forged like iron and steel, of being worked in every way like the most malleable metals or alloys, having added to these properties a color analogous to that of the most precious metal, this bronze proves itself adapted to uses almost innumerable. At first sight, it seems difficult to admit that the relatively small proportions of aluminum which enters into the composition of this bronze can be sufficient to modify so extraordinarily the properties of the copper which constitutes so large a portion of its weight. But we must remember that the specific gravity of aluminum is very low, and that a given weight of this metal possesses a bulk four times as large as the same weight in silver. It follows from this that the ten per cent of aluminum contained in the bronze equals in bulk forty per cent in silver.

The specimens of the ware we have seen, such as spoons, forks, cups, watch-cases, etc., are certainly very beautiful, having the color and high polish of gold, while dilute acids do not affect the surface.

SUBMARINE RAILWAYS.

From "Engineering."

It is sixty years since Trevithick, undeterred by the unsuccessful attempt of Ralph Dodd, began a tunnel under the Thames, working from the Rotherhithe shore. He carried it upwards of 1,000 ft. under the river, and to within 100 ft. or so from the Middlesex bank, when the result of a rash experiment, undertaken by himself, was to flood the works with water. The history of the present Thames Tunnel, now about to become a railway tunnel, is sufficiently well known, and it is also well known that the Botallick mine, in Cornwall, extends for some distance beneath the Atlantic, and it is said that the miners can hear the roar of the waves, or, at least, the crashing roll of the shingle over their heads during storms. Our own columns have contained full accounts of the most important example of tunneling beneath water, viz: the Chicago Lake Tunnel, extending for two miles beneath Lake Michigan, and to a point over which the water is 40 ft. deep, the tunnel itself being 70 ft. beneath the surface of the lake. This work was carried through a bed of imperviable clay, previously bored at a number of points sufficient to establish its perfect continuity, and the tunnel was lined with brick work as fast as the headings themselves were advanced. Here the work was, from the first, as reasonably certain of success as its subsequent progress was easy and straight-forward.

The grandest example of subaqueous tunneling, should it ever be carried out, will be the submarine railway from the South Foreland to the French coast, near Calais. The under sea portion will be 22 miles in length (of course without shafts), under water of a maximum depth of nearly 200 ft. at high tides, and at a distance or depth of from 250 ft. to 320 ft. beneath the bottom of the Channel. A question of great present interest is, Can this tunnel be made? It is well nigh settled, beyond geological dispute, that there is no continuous bed of clay through which it can be carried, unless through a comparatively thin bed of gault of uncertain dip and direction—a bed which, from such examination as it has been possible to make, appears to crop out across the bottom of the Channel between Abbot's Cliff and Cape Blanc-nez. The designers of the Channel Tunnel have preferred, therefore, the lower or gray chalk, and have proposed a line two or three miles only to the north-east of the out-crop just named, with its superior out-crop of green sand. The dip, to the north-eastward of all the strata, is quietly estimated at 100 ft. per mile, although there is not an authenticated axial (longitudinal) section of the Channel in existence, to show what is the real declension, to the north-eastward, of the strata of its bed. The proposed tunnel would pass under the deepest part of the Channel, between Dungeness and the North Foreland, while it would not permit of the shortest crossing, possibly and probably the shortest crossing is not practicable for a submarine tunnel. One enterprising projector would carry a tunnel through the green sand, but those who would carry it through the chalk would still be sailing very close to the wind, with the certainty that if a "fault" or fissure were met with, an irresistible stream of water, under from 200 lbs. to 225 lbs. pressure per square inch, would quickly dispose of all the work previously done. There are large, unmistakable and well recorded faults in the chalk beneath London, and, what with seismotive action—and we *do* hear of earthquakes even in England—there may be larger faults beneath the Channel. That men can be found, by hundreds, to work the headings of a Channel tunnel, need raise no doubt whatever. But that these men would ever come out of the headings, dead or alive, is another matter. If the headings once fail, all hope is well nigh lost. It is proposed, by the engineers to the International Commission, to make two headings from each coast, each 9 ft. square. Two headings are proposed, upon an assigned theory of ventilation, but it is clear that a single heading can be perfectly ventilated by compressed air, while it is certain that two parallel headings would but double the risk without economizing time. With a single heading, 9 ft. square, once safely carried through, there would be no great difficulty in enlarging it to a tunnel 28 ft. or 30 ft. wide. But the roof of this heading, occupying, perhaps, five years in making it, would present a surface for percolation of 24 or 25 acres, and it could not be bricked up as the work proceeded. One, two, or three years after a portion of the heading had been completed, a resistless torrent of water might suddenly come through, destroying not only the whole work, but all within it. To undertake such a work, even if it be not tempting Providence, is, at least, to incur tremendous uncertainties, considering that it would be through a comparatively unexamined bed of chalk, but two or three miles from the outcrop of half a dozen strata.

But supposing the heading, or a parallel pair of headings once made, and the tunnel afterwards made, as it could then easily be made, there would not only be nearly 30 miles of continuous tunnel for the passenger, but this would be upon a line involving a long and circuitous route to Paris. If Paris be the "objective point," it would at least be 25 miles further from London *via* Dover, by Mr. Hawkshaw's, than by Mr. Fowler's route, the latter a steamboat route. From London to Dover is 78 miles by the Chatham and Dover, and 76½ miles (*via* Sevenoaks) by the South-Eastern. To Folkestone the distance is 71 miles only. Yet the proposed tunnel is to be carried well to the east of Dover, say to the South Foreland, and instead of being directed well into the course of the Belgian and North German traffic, it draws short of Calais, and connects more directly with the line between Calais and Boulogne, making it well nigh the most roundabout route between London and Paris.

The Channel Tunnel, estimated at £10,000,000, involving an interest charge, at 4 per cent, of more than £1,275 per day, of 313 working days per year, would admit of any traffic, however extensive, would conduct it at the average working rate of 35 or 40 miles per hour, without detention by tides, fogs, storms or the chances of collisions. It is doubtful whether it can be made, equally doubtful whether it could ever "pay," except in the far distant future, with trains every quarter of an hour. That all trains would require to be lowered 500 ft. or 520 ft. at each end, and again pulled up through the same distance, is by no means an insuperable objection to the tunnel. Nor do we apprehend any insuperable difficulties in the way of draining or ventilating. Both, for anything we can see, may be easily, successfully and permanently managed.

On the other hand, an absolutely certain means of communication, for which nature has provided the "permanent way," if that term may be applied to a tidal sea, is already to be found between Folkestone and Cape Gris-nez, Audrecelles, Ambleteuse or Boulogne. The shorter the sea passage desired, the nearer must the route bear towards Cape Gris-nez. Indeed, Dover pier and Cape Gris-nez are separated by the least distance of any points between England and the Continent, say $17\frac{1}{3}$ knots. But Cape Gris-nez would not make a good landing place for steamers, and so for the Belgian and German traffic, the route would require to be drawn more towards Calais, and so for Paris, it would require to be drawn more towards Boulogne. Of all the existing routes, they are diagonal between two nearly parallel coasts ; in fact, there is no *direct* route across.

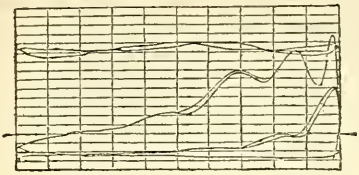
The railway ferry boats proposed by Messrs. Fowler and Wilson, would cross between Dover and Audrecelles, the latter about 7 miles north of Boulogne. By leaving Folkestone instead of Dover, they would save from $5\frac{1}{2}$ to 7 miles of land journeying on the English side, and by making the French port a short distance south of Cape Gris-nez, about two miles north of Audrecelles, they would reduce the sea journey to less than that now attending the Dover and Calais route. To the point named (or rather not named, as bearing no name) the steam service between England and France would be well nigh the shortest practicable. Four or five miles of railway on the French side would connect it with the existing Calais and Boulogne railway, one of the crookedest and worst in France, except between the proposed point of junction and Boulogne. It would be objected that this route would take vessels across the "Varne" and the "Ridge," or "Le Colbert," the most dreaded sand banks, next to the Goodwins, of all in the Channel. But by planting a sufficiently visible beacon on the head of the Varne, a course might be taken to the north-east of it, which would, at low water spring tides, carry over a vessel drawing 24 ft. with more than 40 ft. of water over the north-eastern end or head of the "Ridge."

The tunnel, estimated to cost £10,000,000, and attended with an interest burden of £1,275 per day, might, for twenty trains each way daily, be worked at a cost of less than £200 per day. To perform the same service, probably ten boats, costing each £100,000, would be required, and it is not perhaps far out of the way to allow £1,000,000 for the improvements of the ports of Folkestone and the inchoate port south of Cape Gris-nez, but a little north of Audrecelles. Upon these would rest the interest at 5 per cent, of £100,000 per annum, together with a further sum of £100,000 per annum for depreciation on boats. Beyond these sums would be the cost of repairs of boats, say £50,000, besides coal, wages, &c., bringing the whole, probably, up to nearly or quite £300,000. The boats would not prevent sea-sickness, and they would be more or less exposed to the risks of collision. They might run aground, especially in shallow harbors, and at low tide, and however fast they might be as boats, they would be slow as compared with railway trains, the more so as they would require a considerable interval of time in receiving and discharging their deck load of passenger and goods carriages. Still, this brief examination by no means exhausts the subject.

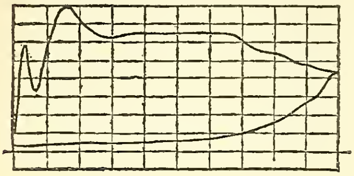
The Bessemer Manufacture in the United States.—The Pennsylvania Steel Works at Harrisburg are regularly making eight five-ton heats every day of twelve hours. This would be equivalent to sixteen heats, or 65 or 70 tons of ingots per twenty-four hours. Eight heats in twenty-four hours is considered fast work in England. It is now over eighteen months since a heat has been lost at these works through the failure of the machinery or refractory materials—a result more remarkable even than the large product. The new five-ton plant of Messrs. John A. Griswold & Co., at Troy, is nearly completed, and will have a greater capacity than any other in this country. The two-ton converter at these works is regularly making ten heats per 24 hours, which is good work for a single vessel. An 18-inch merchant mill, made very heavy and specially adapted to steel, has also been started by this company, and is now turning out bars up to four inches round or square.

Mr. John C. Thompson has resumed the superintendence of the Cleveland works. The Lewistown works are executing a large rail order for the Pennsylvania railroad. The Steel Works of the Cambria Iron Company, at Johnstown, are approaching completion, and will be, in many respects, the finest Bessemer works in this country.

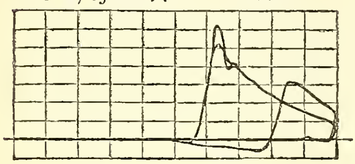
No. 1, cyl. 12″×24″. 200 *rev. per min.*



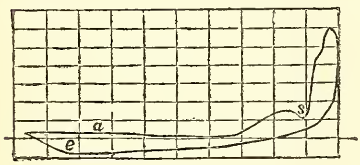
No. 2, cyl. 12″×18″. 95 *rev.*



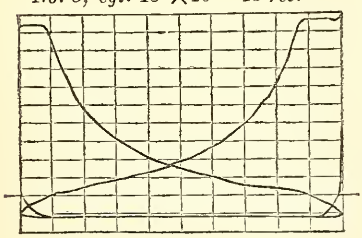
No. 3, cyl. 8″×16″. 60 *rev.*



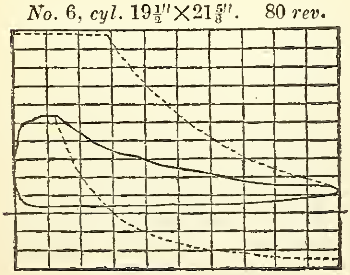
No. 4.



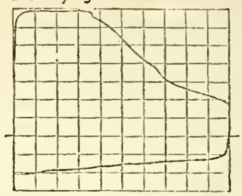
No. 5, cyl. 48″×10″ 15 *rev.*



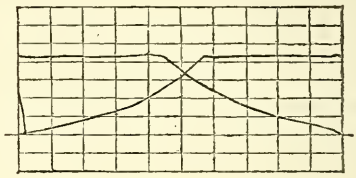
No. 6, cyl. 19½″×21⅝″. 80 *rev.*



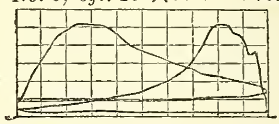
No. 7, cyl. 25 *rev.*



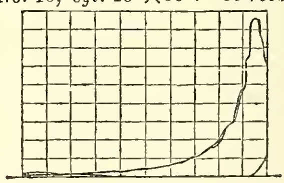
No. 8, cyl. 25 *rev.*



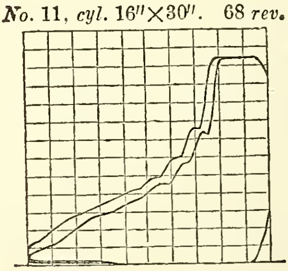
No. 9, cyl. 16″×30″. 68 *rev.*



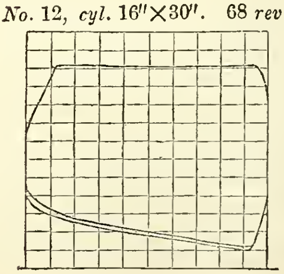
No. 10, cyl. 16″×30″. 68 *rev.*



No. 11, cyl. 16″×30″. 68 *rev.*



No. 12, cyl. 16″×30″. 68 *rev.*



INDICATOR CARDS.

FROM STANDARD AND EXPERIMENTAL ENGINES.

Compiled from the proceedings of the Association of Engineers and Architects.

A suitable description of the Indicator, by which the diagrams referred to in this paper were taken, may be found in C. T. Porter's "Richard's Indicator," published by D. Van Nostrand, of New York.

Diagram No. 1 is from an "Allen" Condensing Engine at the Paris Exposition of 1867. The waving of the expansion line is caused by the excessive momentum of the Indicator piston, due to the high speed of the engine, which cannot be taken up by the spring quickly enough to give the usual regular outline to the diagram. The irregular, nearly horizontal line at the top of the diagram was drawn when the indicator was attached to the steam chest, and shows the pressure of steam as slightly lessened when at the beginning of the stroke a large quantity passes into the cylinder. The atmospheric line is shown in each diagram extending beyond the ends of the rectangle. The spaces between the horizontal lines on No. 1 represent 4 lbs. pressure.

No. 2 is from a Reed and Cogswell oscillating engine. The slow and tardy opening of the steam and exhaust ports is clearly shown. In this 4 lbs. to each space.

No. 3 from a Lenoir Gas Engine. The gas and air pass into the cylinder through valves which close at about half stroke, and the mixture is then ignited by an electric spark, or by other suitable means. 8 lbs. to each space.

No. 4 from a non-condensing engine in a rolling mill at Trenton, and shows the result of an accidental displacement of the pin from which the paper received its motion. The engine has a heavy fly-wheel, and at the time when this diagram was taken, was running without load. The point of admission is at *s*; the opening of the exhaust is at *e*; the back pressure against which the return stroke is performed is shown by the line at *a*; and the rise of the line from *a*, toward *s*, is due to the compression occurring in the cylinder before the beginning of the next stroke.

No. 5 from the U. S. gun-boat "Algonquin," with a Sickles cut-off. 4 lbs. to each space.

No. 6 from an engine having a poppet-valve cut-off, tripped by the action of the governor. 4 lbs. to each space.

No. 7 from the steam cylinder of a condensing blowing engine at Harrisburg, Penn. 6 lbs. to each space.

No. 8 from the air cylinder of the same engine, having valves made of a rubber band, opened and closed by the pressure of the air. 6 lbs. to each space.

Nos. 9, 10, 11, and 12, are all from a non-condensing Corliss engine, at Trenton, New Jersey. No. 9 shows the distribution of the steam by the valves as they had been set for many months previous to the application of the Indicator; and Nos. 10, 11, and 12 give the improvement shown by its use to be needed and entirely practicable. It was effected by merely moving the eccentric ahead upon the shaft so that the valves were all opened earlier. In all these, 6 lbs. to each space.

No. 12 shows a high back pressure with the engine following full stroke. No. 11, the distribution of steam when cut of at $\frac{1}{4}$ stroke, and No. 10, when no work was done except driving a fly-wheel and gearing, by which the power was transmitted to the train of rolls.

LEAD AS A COVERING FOR ROOFS.

By Mons. C. Détain, C.E., in "Revue Générale de l'Architecture."

Properties of Lead.—Lead is of a bluish-gray color, usually dimmed after being submitted to the action of the air, but lustrous when recently cut or scraped. It remains unchanged for some time in a dry atmosphere, but if subjected to the action of humid air it soon becomes covered with a blackish pellicle. This coating preserves the rest of the metal from oxidation, in the same way that a covering of the same nature preserves, with even greater efficacy, zinc surfaces. "Pure lead is not affected by perfectly pure water free from air, but if air be present the metal is oxidized at its expense, and the oxide thus formed, combining with carbonic acid, is deposited on the lead in minute crystals as a basic carbonate of lead. The water will then be found to contain lead in solution, and such waters drawn from impure cisterns, often produce very distressing consequences. If the water contains any sulphates, the lead is thrown down as a sulphate of lead, which is insoluble." ("Ure's Dictionary," 6th edition.)

In a state of purity lead is very soft—it may be scratched with a finger nail, and readily cut with a knife; rubbed upon paper it makes a metallic gray stain. Its malleability is very great, so great that it may be beaten into thin leaves and drawn into very fine wire, but it has but little tenacity—only about one-fourth that of zinc. A wire of one-twelfth of an inch diameter will not support 20 lbs. Lead which has been prepared by the old method, that is to say, by casting, much in the same way that plate glass is manufactured, has about the same tension as rolled or milled lead, but the cast lead breaks abruptly, presenting a clean, granulous fracture, whilst rolled lead, before giving way, is drawn into threads, so to speak. The rolling process has a great influence upon the ductility of this metal. The result of numerous experiments is that relatively laminated lead is to cast lead as 7 is to 5. The ductility of the latter kind appears to be the same for all thicknesses, whilst that of laminated lead appears to increase with the hammering to which it is subjected. Cast lead is firmer and drier, as the workmen say, than rolled lead. Its surface is marked by an infinite number of minute pores, which give it a rugose appearance. Rolled lead, on the other hand, has a very smooth surface.

The density of lead when pure is 11.445. The lead of commerce, however, is very rarely pure; it very often contains copper, iron, and even traces of silver, antimony, arsenic, sulphur, &c. Thus its density rarely rises above 11.352—one and a half that of zinc. Hammering does not appear to increase the density of lead, it diminishes it rather. It commences to fuse at 325° C.; before fusing it is covered with an iridescent pellicle of great beauty. As the temperature rises the colors disappear—at 335° C. it is in a complete state of fusion.

The prolonged contact of lead with another metal, will lead to its being destroyed by the electrical action which is set up. M. Détain quotes a case which came within his experience. The roof of a bathing establishment was covered with copper, but at one point lead was used in contact with the former metal. After a time the roof began to leak. A workman was called in. The lead was found completely oxidized; it had kept its form, but on being touched it crumbled into powder. The lead was likewise in contact with an oak plank, and its destruction was due to three causes: contact with the damp wood, the action of the vapor of water, and electrical action.

Lead is very rapidly altered by contact with damp plaster; sulphate of lead is then formed, which is a most energetic oxidizing agent. Saltpeter or niter also attacks lead very powerfully. Saltpeter is very often to be found in damp cellars, and upon the walls of wells; thus it is very commonly the destruction of the lead pipes in pumps, which under these attacks become perforated in many places. Again, lead is subject to the attack of certain insects which gnaw very minute orifices in it. It appears that old lead is not so liable to these attacks, and the inferiority in this respect of modern lead, is attributable to its being now-a-days too much refined, which, together with the rolling process, tends to weaken its structure. The texture of rolled lead is, so to speak, formed of a number of leaves, which are capable of being separated without much difficulty. Nevertheless, laminated lead is not the sole kind liable to these insect attacks. Marshal Vaillant not long since presented to the French Academy of Sciences some bullets which had been deeply eaten into in this way. Lead has about half the heat-conducting power of zinc. The power of lead, in this respect, is represented by 180, that of zinc by 363.

Nearly all the lead which is employed in the arts is extracted from the ore called galena or sulphide of lead. "This is the most abundant ore of lead; it may be, indeed, regarded as the only commercial ore of any value, if we except the carbonates, which are probably formed by the decomposition of galena."—("Ure's Dict.") This ore is found in all the lead producing districts. Thomson's analysis of galena gives:

Lead	85.13
Iron	0.50
Sulphur	13.02

Lead is found in almost every country. The beds are numerous, and next to iron the most widely spread; but the richness of these beds is very unequal. It is found almost in every kind of stratum, sometimes in thick and productive seams, sometimes only in "pipe veins," sometimes disseminated in grains.

England and Spain are at the head of lead-producing countries. England produces 70,000 tons; Spain 60,000 tons; Germany produces only about 10,000 tons; France produces but the insignificant amount of 200 tons annually, whilst to supply her wants she has to import about 80 times as much more.

Lead in its employment for Roofs.—The layer of lead upon a roof must be sufficiently thick to resist the influence of the coating of oxidized matter which will overspread its surface under the action of the atmosphere, and also to resist being torn and cracked by the force of the contractions and dilations which variations of temperature may cause it. The tenacity of lead is four times less than that of zinc, and at the same time its linear dilation is the same. In order then that lead may present the same resistance as zinc, it must be four times as thick. It is true that lead resists the destructive action of winds more successfully than zinc, on account of its greater weight and its better adherence to its supporting timber; but this very weight may prove an element of its early decay in the case of roofs which are of a very steep incline. We must also take into account that a roof covered with lead will cost six times as much as one in which zinc is used. Nevertheless, in making a comparison between the monetary value of lead and zinc, we must always remember that there is a vast difference in the ultimate intrinsic value of the two metals; lead after being used loses but little of its first value; whilst zinc loses considerably more than one-half.

If a lead roof is heavier and dearer than one of zinc, it is superior to it in appearance. It very quickly assumes a uniform dark aspect with grayish reflections; whilst zinc very slowly puts on a dirty black color, without any reflections. No experienced eye could be deceived as to the two metals, even at some distance. Lead has a rich, substantial look, whilst zinc is characterized by a mean, flimsy and cheap appearance, which must greatly detract from the beauty of any building of importance. The roof of Notre Dame, which is formed of lead, has a beautiful appearance, to speak of its color alone; the roof of St. Clotilde, on the contrary, formed as it is of zinc. has a poor and commonplace look. This fact is so fully admitted by the French builders, that in Paris, where, in house building, zinc is largely employed, those parts which are very prominent are colored black to resemble lead. This coat of oil paint, however carefully it may be prepared, adheres only badly to the metal, for in a short time it scales off and falls away in pieces. Another process has been tried with much effect, as it has been alleged. This is to paint the zinc with a hot solution of graphite, in water strongly charged with caustic and fixing substances, as for example, chlorate of potash and sulphuric acid; 14 parts of graphite, 1 of chlorate of potash diluted in 28 parts of sulphuric acid, commonly called vitriol. The whole of this compound must be gently heated, and watered to a consistency such as may be easily laid on with a brush. It is a good method, first of all, to wash over the surface of the zinc with a weak solution of sulphuric acid, which will cause it to take the paint more perfectly. The paint must be laid on hot.

Formerly, the lead was of a thicker kind than that now in use. This is one of the reasons why modern leaden structures are less durable than the old. Besides having regard for the proper thickness of the sheet of lead, we must always take into account the special qualities of the metal. Thus, when it is placed in position where it may expand with facility, we must, if possible, only nail it upon one end. The nails should be of a large head, and placed closely together. Lead should never be placed in contact with wet wood or damp plaster; and the proximity of another metal less oxidizable, should always be avoided. Finally, lead should never be subjected to the action of the vapor of water, because the water upon being condensed upon the surface of the metal is very much aërated, and in this condition acts very energetically upon lead, as we have already seen.

Soldering.—Lead is soldered by means of an alloy of that metal with tin, or simply by itself without the employment of any intermediary alloy, by the method known as "autogenous soldering." For the soldering of large and heavy work, the proportions of the alloy should be 30 tin and 70 lead; for lighter varieties of workmanship, 70 tin and 30 lead.

With respect to autogenous soldering (lead with lead, without using any intermediary alloy), it is only made use of in very great works, and in producing leaden vessels for the manufacture of chemical products, where the acids which act upon tin would very quickly destroy the ordinary solder.

This new method of soldering was invented by Count Desbassayns de Richemont. "Hydrogen gas is contained in a gasometer to which a flexible tube is connected, and air is urged from a bellows worked by the foot through another tube and on to the blowpipe where the hydrogen is ignited. By means of the flexible tubes, the flame may be moved up and down the line of any joint, and the connecting medium melted."—(Ure's Dictionary.) In our naval arsenals this process has been largely employed. This kind of soldering renders the joint very strong, the junction being as firm as any other part of the surface of the metal. The process is capable of being used in all kinds of plumber's work.

In France, especially, lead roofs are formed in two ways: In the shape of slates and used in the same way, and in sheets. Leaden tiles are used only in the case of very pointed steeples, or domes of small dimensions, and in analogous circumstances. When sheet lead is used on steep roofs, it must be firmly secured, and at the same time it must be allowed the means of dilations. The new roof of the Cathedral of Notre Dame, at Paris, is made of cast lead. The celebrated Dome of the Invalides, in the same city, recently repaired, is likewise of cast lead. Both these roofs have a deservedly high reputation for beauty of appearance and excellence of workmanship.

THE IRON AGE OF SHIP-BUILDING.—The first large, square-rigged iron sailing-vessel ever built in this country was successfully launched August 5th, from the yard of Messrs. Harlan & Hollingsworth, at Wilmington, Del. This vessel, a bark, was built for Messrs. Tupper & Beattie, of this city, and is said by competent judges, who have examined her, to be in every respect equal to the best Clyde-built ships. She registers 700 tons, new measurement, is 155 ft. over all, 140 ft. keel, 31 ft. 9 in. beam, $11\frac{1}{2}$ ft. depth of hold, is 7 ft. between decks, has all the modern improvements, and is very appropriately named the Iron Age. She has a yacht stern, upon which is placed the attractive and appropriate coat-of-arms of the State of New York. Her prow is sharp, and has for a figure-head the bust of an artisan, with a cold-chisel in one hand, and a hammer in the other, emblematic of his craft.

This vessel was built upon British specifications, and at a cost, we are assured, not exceeding the best Clyde-built ships, or, indeed, the cost of constructing a first-class wooden ship at this port at the present time, a special contract rate having been secured. In several essential particulars the Iron Age is an improvement upon any British iron ship which has visited our ports. The angle iron used in her construction is considerably heavier than that employed by the Clyde and Mersey builders; her ribs are from two to four inches closer together than British ships, while in her framing there has been no piercing or bursting of rivet-holes, which is something unusual in this class of vessels. In point of model, sailing qualities and carrying capacity have been judiciously blended. All the British iron ships that we have seen, are long and narrow, thus rendering it necessary to ballast them before receiving, and after discharging cargo. The Iron Age has sufficient breadth and curvature to obviate such a necessity. She has already been surveyed by the agents of the American and French Lloyds, and pronounced by them one of the best specimens of iron ships. When launched and ready for rigging her draught of water was only 4 ft. 11 in. forward, and 6 ft. aft, which is a foot lighter than a wooden ship of the same dimensions.

While the first cost of an iron ship is greater than that of a wooden vessel of the same size, the former, in the end, is much the more economical. It has been abundantly demonstrated that the use of iron instead of wood gives to the vessel greater strength, combined with lightness—two important considerations in ships. An iron ship, moreover, is not subject to the intense straining which is so severe upon the joints of the wooden vessel. The facility which iron gives in the construction of a vessel is much superior to that of wood, because there is no useless metal employed, and no filling is required. The power of iron to resist tension and compression is also much superior to that of wood. In the preparation of the material for the construction of a vessel, there is great economy of time and labor in the use of iron. The superior strength of iron vessels, and the tenacity of their frames in contingencies fatal to wooden vessels, are illustrated by a long practical experience. The use of iron increases the capacity of the vessel for stowage, thus rendering this kind of tonnage far more profitable, to say nothing of durability. A first-class wooden ship will rate A 1 for but nine years, while a first-class iron ship will stand the same rate for twenty-one years. And the iron ship, with no unforeseen casualty, will be good property long after a modern wooden ship has gone out of existence.

The days of wooden ships, it is safe to conclude, are about numbered. In Great Britain, iron has become the standard material for ship-building, and in other maritime countries a similar change is beginning to take place, so that in another decade, probably, wooden ship-building will be out of date. Although the United States, for obvious reasons, is behind the leading nations of Europe in this branch of industry, it may safely be taken for granted that we are not likely to remain long in the background. We want cheaper materials to begin with, and if Congress cannot frame a law for the benefit of ship-builders without exciting a conflict of interest among other classes of home producers, it must inaugurate prompt reform in national finances, such as shall bring down the cost of production to its natural level. Something must be done, without longer delay, to resuscitate an interest that has been, in years gone by, the bulwark of our commerce, and to rescue our valuable carrying trade from the flags of other nations.

The Iron Age is the third iron sailing-vessel ever built in the United States, the other two being the schooner Mahlon Betts, built at Wilmington, Del., and the iron brig Novelty, recently built by the Atlantic Iron Works, Boston, for carrying molasses in bulk. Both are much smaller than the vessel launched at Wilmington last week.

Wilmington has important advantages over any other American port in this branch of industry. She has iron and coal in abundance at her very door, together with long years of experience. The firm who built the Iron Age have built upwards of two hundred iron steamers, varying in size from 300 to 1,500 tons. They have built for one firm alone, twenty-one steamers for the Gulf trade, and they have been thirty-three years maturing their plans to carry on this important branch of industry. They employ at present 600 hands, but have facilities for employing more than twice that number, should their business warrant it.—*N. Y. Shipping List.*

RESISTANCE OF ROADS TO TRACTION.—The following results of the experiments of Sir John McNeill in regard to traction on roads of different kinds, are pretty generally accepted as accurate:

Resistance in pounds per ton on different roads.

Iron floor	8 lbs. per ton.
Stone tramway	20 lbs. per ton.
Paved road	33 lbs. per ton.
Macadamized road	44 to 67 lbs. per ton.
Gravel	150 lbs. per ton.
Soft, sandy and gravelly soil	210 lbs. per ton.

STEAM-ENGINE PERFORMANCE.

From "Engineering."

Since the publication in a recent number* of the particulars of the experiments made by Messrs. Farey and B. Donkin, jr., on an engine at Messrs. B. Donkin & Co.'s works at Bermondsey, we have received from Mr. John Pinchbeck the details of a trial conducted by him some years ago of a single-cylinder engine constructed by the Reading Ironworks Company, then Messrs. Barrett, Exall & Co. In this trial the temperatures of the water supplied to, and thrown off from the condenser were accurately noted, and the quantities both of the condensing water and of the water evaporated were carefully weighed, as was also the fuel used. In order that the quantity of water evaporated might be ascertained with accuracy, the water was weighed before filling the boiler, and on the experiment being completed the boiler was blown off, and the water thus blown off also weighed. The difference between these first and final weighings had, of course, to be added to, or subtracted from the weight of the water supplied to the boiler during the trial, in order to get the true evaporation. The weighing of the water discharged from the condenser was managed as follows: A wooden tank, measuring about 4 ft. × 4 ft. × 4 ft., was placed on the table of a weighing machine and accurately balanced, and weights amounting to one and a-half tons were then placed on the scale beam. The water in the condenser was then run into this tank until the weights we have mentioned were lifted, when the communication with the hot well was shut off by a sluice, and another sluice opened which allowed the water to run out of the tank. While the main tank was being emptied, the water discharged from the hot well was received in a small auxiliary tank, which was, of course, emptied into the main tank as soon as the latter was ready to be refilled. The number of times that the main tank was filled and emptied was, of course, registered, and the weight of water discharged from the condenser was thus obtained very accurately. Altogether this trial of a single-cylinder engine is one which forms an interesting comparison with that of the engine of the double-cylinder class, of which we gave the details last week. The particulars of Mr. Pinchbeck's experiments are as follows:

* See V. N.'s Mag., Aug., p. 693, and Sept., p. 787.

Description of Engine.—Horizontal high-pressure condensing. Cylinder 21 in. in diameter, with 30 in. stroke. The cylinder and covers steam-jacketed, steam being supplied direct from the boilers, and means being provided for getting rid of the water resulting from the condensation of the steam. Distribution of the steam effected by slide-valve with adjustable expansion valves at the back, worked by separate eccentric. During the trial the cut-off took place at $3\frac{1}{8}$ in. of the stroke.

Boiler.—Cornish, 22 ft. long, 5 ft. in diameter, with single flue 32 in. in diameter. The boiler was fed from the hot well, the water being pumped through a heater fixed in the boiler flue.

Duration of experiment	10 hours.
Quality of coal used	Duffryn steam coal.
Quantity of coal used	11 cwt.
Quantity of water evaporated,	1,108 gallons.
Quantity of water evaporated per lb. of coal	9 lbs.
Pressure of steam	50.9 lbs. per sq. in.
Mean vacuum	27 in.
Quantity of water thrown off by condenser per minute	410 lbs.
Mean temperature of water used for condensing	38°
Mean temperature of water as discharged from condenser	82°
Revolutions of engine per min., by counter	60.03
Power developed (indicated)	47 H. P.
Power developed, as measured by brake	40 H. P.
Consumption of coal per hour per indicated horse-power	2.6 lbs.
Consumption of coal per hour per dynametrical horse-p'r,	3.06
Ratio of expansion, allowing for clearance, etc	1 : 8.6

It will be seen, from the above particulars, that the mean vacuum and the indicated power developed, are practically identical with those obtained during the trial of Messrs. B. Donkin's engine, and the consumption of coal per indicated horse-power per hour is also the same. It will be remarked, however, that the pressure of the steam is 10 lbs. higher than during Messrs. Farey and Donkin's trials, and that—owing probably to a better quality of coal being used—the evaporation of water per pound of fuel was higher than in the case of these last-mentioned experiments, being 9 lbs. against 8.72 lbs., and this circumstance should, as we pointed out in our previous article, be taken into consideration in comparing the performances of the two engines. Adopting the far better method of comparison proposed by Messrs. Farey and Donkin, and already fully described by us, we find that the quantity of heat discharged into the condenser, per indicated horse-power per minute, was more than 16 per cent less in the case of Messrs. B. Donkin and Co.'s engine, than in that of the engine tested by Mr. Pinchbeck. Thus, in the latter instance, the average quantity of water discharged from the condenser was 410 lbs. per minute. This quantity of water was heated from 38° to 82°, or 44°; and multiplying 410 by 44, we get 18,040 as the number which, divided by the indicated horse-power developed, gives Messrs. Farey and Donkin's "constant." In the case of the engine tried by Mr. Pinchbeck, this "constant" is $\frac{18,040}{47} = 383.8$, while the "constant" obtained during the trial of Messrs. B. Donkin & Co.'s engine was 322.87, or 16.2 per cent less. Considering that the quantity of fuel burnt, per indicated horse-power per hour, was the same in the two cases, and that the evaporative value of the fuel varied but about three per cent, the above difference of 16.2 per cent in the quantities of heat respectively received by the two condensers, appears, at first sight, somewhat difficult to account for, even if we suppose that in Mr. Pinchbeck's experiment the hot well received all the water discharged from the steam-jackets. If, however, we analyze Mr. Pinchbeck's experiment more minutely, we shall find that the various results agree very closely, and that any errors of observation which may have occurred, must have been very small. If this had not been the case, we might have supposed either that the quantity of water evaporated must have been somewhat greater, or the quantity of condensing water must have been less, or have been less highly heated during its passage through the condenser. Thus, 1,108 gals. of water were evaporated during the ten hours = 1,108 lbs. per hour = 18.46 lbs. per minute, and, of course, the same quantity of water returned to the boiler as feed at a temperature (the feed being taken from the hot well) of 82°. The total heat of steam, at a pressure of 52 lbs. above the atmosphere, is 1,205.4°, and the quantity of heat withdrawn from the boiler, per minute, was thus $(1,205.4—82) \times 18.46 = 20,737.96$, or, say, 20,738 thermal units. If now we suppose (as was probably the case) that the water discharged from the steam-jackets found its way into the hot well, the manner in which the above quantity of heat would be disposed of would be as follows: Subtracting from the 410 lbs. of water discharged from the condenser per minute, the 18.46 lbs. resulting from the condensation of the steam, we get 391.54 lbs. as the quantity actually raised in temperature 44°, and $391.54 \times 44 = 17,227.76$, or, say, 17,228 thermal units of heat are thus accounted for. Again, the quantity of heat actually converted into work would be $\frac{33,000 \times 47}{772} = 2,009$ units, and there would thus be but 1,501 units to be accounted for by losses by radiation, etc. The summary would be as follows:

	Thermal units per minute.
Converted into work	2,009
Imparted to condensing water	17,228
Lost by radiation, etc	1,501
	20,738

We have said that the difference of 16.2 per cent in the "constants" obtained in the two cases we have considered is, under the circumstances, somewhat difficult to account for; but it is no doubt due to the fact that, not only was the expansion carried to a less extent, but both the initial and final temperatures of the condensing water were, in the case of the engine tested by Mr. Pinchbeck, lower than in the case of the engine at Messrs. B. Donkin & Co., although the vacuum was the same in both cases. Of the effect of such differences of temperature and of the degree of expansion on the "constants" proposed by Messrs. Farey and B. Donkin, jr., we intend to speak fully on an early occasion; and we shall then show that the fact of such differences having the effect we have stated, in no way diminishes the value of the "constants" as standards of comparison, but, on the other hand, rather increases it.

FRENCH MILITARY TELEGRAPHS.

Translated for "Engineering" from "La Télégraphie Militaire," Paris, 1869.

The following are details of the military electric-telegraphic apparatus used in the experiments in the camp at Chalons, last summer:

Electric Telegraph.—For military purposes it is desirable that the apparatus should not only be simple in itself, but should be capable of being used in connexion with the permanent lines of telegraph already established. Keeping these ends in view, a modification of Morse's recorder, constructed by M. Duguy, from designs furnished by the Bureau des Télégraphies, and known as Le Poste Militaire, was adopted and found to answer well. This apparatus is contained in a box, to the bottom of which it is secured by slides. The manipulator is placed on the right of the small shelf supporting the recorder; on the left are the galvanometer to show the strength of the current, and a paratonnère to protect the operator from the shock of unforseen accumulations of electricity in the wires in stormy weather. The sides and front of the box fold down, so as to permit of the instrument being used without necessitating its removal from its case.

The connection between the stations was kept up partly by wires, partly by a cable laid along the ground.

Wires.—These were of copper, 1.6 mil. in diameter, weighing 22.5 kilog., and costing about 100 francs per kilom. This wire proved an excellent conductor, and, with care, could be used with intervals of 200 and 300 m., or even more, between the supports.

Cables.—Several kinds were tried. In the last experiments the cable was formed of a core of five annealed copper wires, bound round with white cotton thread, over which was a coating of gutta-percha, and then a layer of oakum, the whole being bound round twice with cotton tape steeped in vulcanized india-rubber. It weighed 35 kilog., and cost 320 francs per kilom. It was perfectly insulated, and a good conductor. When laid along the ground it suffered little from wheels and the feet of horses passing and repassing over it. But it had serious defects. It was rather too large in its diameter, and very weak, stretching sufficiently to injure the core with a strain of 30 kilog., and breaking with one of 40 kilog. The wires of the core were so fine as to be frequently cut through in removing the covering for the purpose of splicing.

Supports.—The wires were supported on light staves called lances, 3 m. 80 c. in length, 200 of which made a military wagon load. They were sunk 12 in. in the ground, and weighed up with wooden pickets. Where the line made an angle, the lances were strengthened with guy-ropes, known as haubans, attached to iron pickets. The lances could be lengthened by attaching two or more, end to end, by means of rings called anneaux de rallonge, fitted with clump screws.

Insulators.—With spires of india-rubber made hollow so as to fit over the end of the lances, and surmounted by a small cylinder of the same material. The wires were attached to the insulators by a couple of turns.

Iron cramps were also supplied which could be driven into the ground, or into the walls and trees *en route* to support the cable when used in place of wires.

For the transport of this *materiel* four-horse tilted wagons were provided of three descriptions. Each wagon was supplied with lamps arranged for external or internal use, and carried a distinguishing flag marked with a T in front. The draught in "marching order" is not stated, neither are the kinds of timber used in their construction of the wagons specified. The voiture poste, or traveling telegraph office, was in two compartments—the front serving as an office, the rear containing reels for the wire or cable. On the left of the front compartment (which was furnished with small windows) was a table, to the top of which was screwed the case containing the telegraph. On the right was a seat for two operators, under which were placed the batteries. The "earth connexion" was maintained by means of a wire communicating with the iron axle-tree, which in its turn was connected by means of the brass axle-tree boxes, and a metal rod running along one of the spokes with the tyre of the wheel. The connexion was thus independent of the movements of the vehicle. Where a good "earth" could not be found the wheels were wetted from time to time, or the wire was detached from the axle-tree, and tilted to a hollow iron picket provided with holes and filled with water,* which was driven into the ground under the wagon. This could of course be done only during a halt.

The other wire was connected with the metal work supporting the reels, and through it with the iron cheeks of the latter, against which one end of the wire or cable was clamped. These two wires, like those connecting the telegraph with the batteries, were of copper coated with gutta-percha. The contact was secured each time the telegraph was put in work, by means of small brass button-headed screws, known as bornes, serrés fils, and serrées lames.

The sides of the front compartment were fitted up with drawers and pockets for carriage of spare stores, etc. The hind compartment held eight reels, four on either side. The cores, cheeks and axles of these reels were of iron, the other parts of wood. The axles revolved in sockets fixed on two iron rails running along the sides of the compartment, and known as chemins de fer. Some ingenious arrangements were provided for regulating the motion of the reels, and protecting the hands of the men working them.

Each reel carried 5 kilom. (130 kilog.) of wire if required. But as 90 kilog. had been found to be about the maximum weight of a reel to be perfectly manageable, it was considered preferable to have 2 to 3 kilom. only on each, or 1 kilom. of the cable above described. The total interior length of the voiture poste was 3 m. 20 c.

The chariot poste-bobine, or wire wagon, was similar in exterior to the above, but somewhat longer, the interior length being 3 m. 90 c. It carried twelve reels, six on a side, each having 3 kilom. of wire. The lances, thirty or forty in number, were racked longitudinally between the two rows of reels. Each wire wagon carried also a supply of pickets, wood and iron, insulators, ropes, &c., &c.

One voiture poste with its accompanying chariot poste-bobine was estimated to carry a length of wire equivalent to an average day's march of 20 kilom. (or $12\frac{1}{2}$ miles.) The poste centrale resembled the voiture poste without the reels, the whole interior being fitted up as a telegraph office. Two ateliers, or squads, each consisting of one sergeant, two corporals, and twelve soldiers —exclusive of drivers, buglers, &c.—were told off to each voiture poste with its accompanying wire wagon.

In addition to the arrangements above described, an equipment for mountain service was provided on the following plan—this was called the poste roulante:

A mule or pack-horse carried two panniers, one on each side, one holding the telegraph apparatus, the other the battery, the weight of the two being equal; each case being also provided with drawers for the carriage of insulators, cramps, &c., so arranged as to allow of their being opened without removing the panniers from the mule's back. Across the top was packed a small light square tent, to serve as an office, and a tripod table for the apparatus, an iron picket for "earth connexion," and a bag of tools. A second mule or horse carried two reels with their supply of wire, slung pannierwise across a pack-saddle by means of chains.

* A supply of water was carried in a small gutta-percha cistern fitted in rear of each wagon.

As the unwinding of the reels on the mule's back would not only alarm the animal, but also disturb the balance of the load, a small wheelbarrow was also provided, light enough to be lifted up in the hands if necessary, and fitted to receive one pair of reels. The mallet required for driving the picket could be used as a handle, so as to enable a man to push the contrivance before him without stooping.

This little barrow often proved of great service, even with the wagons, in passing over broken ground. In crossing streams, too, it could be placed in the stern of the boat, thus greatly facilitating the "paying out" of the cable.

The operation of laying down the line was conducted as follows: A wire-wagon, followed by its voiture poste, marched first, both wagons halting from time to time to allow of the working party keeping a little ahead of them. The signals for advancing and halting were given with a whistle. The working party usually consisted of one atelier (15 men) divided into three subdivisions, and without arms or packs.

The sergeant marched at the head, marking out the line foot by foot. The first subdivision followed, digging the holes for the lances usually at 50 to 60 m. apart, or when cable was used, digging the little trenches to receive the latter at points where roads had to be crossed, fixing the cramps for its support at distances varying in accordance with the nature of the ground, &c. The second party unwound the wire or cable, making the splices and joints. The third then attached the wire to the lances fixing the latter; or laid out the cable, filling in the trenches where such were made for it, and finishing the line generally.

The work was very arduous. The average rate obtained on the most favorable ground was two kilom. the hour with suspended wires, and five kilom. with cable. In passing villages, &c., double the above time proved requisite.

For taking up the line, five or six men marching in inverse order were sufficient. The rapidity with which this manœuvre was executed equaled and sometimes exceeded that of ordinary route marching.

In joining the lengths of cable, the covering was first removed and an elastic india-rubber tube slipped over one length, the wires were then spliced and the india-rubber tube drawn over the joint and secured by tying down the ends firmly with twine. This was found to answer perfectly; but as the tying process took up some little time, small cylinders were sometimes substituted for the india-rubber tube. These contained two india-rubber discs having holes in them for the passage of the cable, and hollow screws at each end working against them. The screws were made hollow so as to allow of the passage of the cable through them. The splice was made in the ordinary way, the tube drawn over the joint and the discs compressed round the cable by the action of the screws. A joint could be thus made in thirty seconds. It was found, however, that the vibration of the cable loosened the screws and allowed water to leak into the joints.

The experiments at Chalons were conducted by a corps formed provisionally of detachments of the different regiments in the camp, under the superintendence of some officers of the Etat Major, assisted by some *employés* of the Administration des Télégraphes. They were of various kinds. On one occasion when a series of manœuvres were executed in presence of the Emperor, parties of the telegraph corps accompanied each division. Communications were kept up between the divisions and the head-quarters, and with the telegraph station at Mourmelon through which despatches were transmitted to Paris. On another occasion a party of the corps, with a voiture poste and wire-wagon, accompanied a cavalry reconnaissance to a distance of 8 kilom. from the camp. They laid down a line of telegraph, transmitted several reports to camp, and took up the line again in time to re-enter the camp with the cavalry.

The crowning experiment was made on 30th July. A party of the telegraph corps, consisting of four officers, two civil *employés*, 70 men, five wagons, including a forage cart with the baggage, and 30 horses and mules, marched from the camp at midnight with provisions for two days. A line of wire, 7 or 8 kilom. in length, had been established the evening before. The night was very dark. The party arrived at its destination at 1 A. M., and immediately commenced the prolongation of the above line, with the aid of lanterns. By 6 A.M., 24 kilom. of line had been completed, and guards established along it. The party bivouacked at Perzy. The line remained in use 36 hours. At 5 A. M., on 1st August, they started again for Chalons, and re-entered the camp at 10.30 A. M., having brought in the whole of the line of telegraph.

These experiments were considered highly satisfactory. We learn, however, that the Imperial Government has not considered it expedient to establish a separate corps for telegraphic purposes at present; the *materiel* has accordingly been made over to a company of the Corps du Génie, by whom the duties are in future to be performed.

WHITE PIG-IRON IN THE BESSEMER PROCESS.

By Dr. Adolph Schmidt.

It has been found by numerous experiments, made and repeated in all iron and steel making countries, that white or even mottled pig-iron cannot be worked to advantage in the Bessemer converter. The most celebrated brands of Bessemer pig are gray and graphitic to such an extent as to be almost unfit for foundry purposes. When white or mottled iron is used in the Bessemer process, the first or slag-forming period, which with good working irons, lasts from nine to twelve minutes, passes over in five or six, and as the duration of the second and third periods is generally unchanged, the whole charge is thus shortened about five minutes. In the second or boiling period of the process, when the carbon is in full and rapid combustion, and a bright flame with sharp outlines is rushing through the mouth of the converter, white iron causes vehement eruptions, and thereby considerable losses of metal.

During the third or finishing period, the flame appears then mostly dull and pale, indicating a comparatively low temperature of the metal in the converter. The reaction of the recarburizer is slow and weak. The final product, though sometimes of a bright appearance in pouring, chills easily in contact with less hot objects. Parts of it stick to the interior walls of the converter, especially near its mouth, and a heavy scull in the ladle is unavoidable. It is evident that a favorable percentage of ingots cannot thus be obtained.

The product is, besides, not of a very good quality. Though the white iron may be good and pure, the Bessemer metal made from it shows frequently this peculiarity—that it can be worked perfectly well at a red heat or at a white heat, but that it cracks and even crumbles to pieces when hammered at an intermediate or yellow heat. This deterioration by a yellow heat goes in single instances so far as to make a bar, which is heated yellow, break off in being simply bent. This peculiarity, which no other but Bessemer metal ever shows, is often the consequence of a cold charge. It has been called "shortness" in Sweden and Austria, where it sometimes occurs with the best brands of iron. After the analogy of the word "red-shortness," which is in general use, "yellow-shortness" would perhaps be a more appropriate expression.

The effects above described are produced by most white or mottled pig-irons when subjected to the pneumatic process, the spiegeleisen not excepted.

The short duration of the charge, and the coldness of the product, leads us to suppose that a lack of carbon might be the cause of all this. If not only carbon is taken into consideration, but also silicon, sodium, potassium, aluminium and other ingredients which, at moderate temperatures, have more affinity for oxygen than carbonhas, this supposition appears to be well founded. For, though a good white iron contains generally nearly or quite as much carbon as a gray iron, the latter, however, being made at a higher temperature, always contains a much greater quantity of silicon and other matters which require a high temperature to be reduced, and the total percentage of carbon and silicon, etc., is always higher in a good gray iron than in a good white iron, provided that the latter has not been made white artificially by sudden cooling in water or in iron molds.

When an iron containing a considerable amount of silicon is worked in the Bessemer converter, four-fifths of the silicon and only one-third of the carbon are burnt during the first period, which takes over one-half of the time of the whole charge. It is seen, from this fact, that the greater part of the carbon is saved for the latter half of the charge, and can then exert its full heating power on the iron, the latter being heated up slowly and gradually by the previous combustion of the silicon. When, on the contrary, a pig-iron without silicon is converted, the carbon enters very soon into full combustion. The difference between the temperature of the gases produced and that of the molten iron is then so great, that the rapidly escaping gases carry off uselessly a great quantity of heat which otherwise might benefit the iron, and the greater part of the carbon is consumed before the time when the heat would be most required and most useful.

The heat produced by the burning silicon is also more fully utilized than that produced by the burning of the carbon, because the product of the combustion of silicon, viz: silicic acid is not gas, but a solid substance, and does not escape rapidly, but combines with the slag, and is thus retained in the converter, where it has ample opportunity to communicate its surplus heat to the metal.

It seems, therefore, that not exactly a lack of carbon alone, but that a lack of "fuel" in general, that is to say, too small an amount of all the substances which by their combustion produce the heat in the Bessemer process, is the real cause why white or mottled pig-iron cannot be worked to advantage. Guided probably by these considerations, Mr. Edward Stockher, general director of the Imperial Iron and Steel Works at Neuberg (Styria), has conceived the idea of adding fuel to the Bessemer charge in case the pig-iron should not be sufficiently gray to make a hot charge by itself. He proposed, and tried with success, blowing charcoal dust into the converter.

The first trials were made in 1867, and since that time charcoal has been used regularly in almost all the charges. At Neuberg, the pig-iron is generally run from the blast furnaces into the converter without being remelted. The iron must be highly graphitic to make hot Bessemer charges and to produce a good metal. To insure this desirable effect, independently of the unavoidable little irregularities in the blast furnace, a great amount of charcoal had to be used for the production of the pig-iron, and the furnaces had to be conducted with the utmost care. Since the introduction of Mr. Stockher's method of blowing charcoal dust into the converter, a saving of 22 cubic ft. of charcoal is effected per ton of iron without injuring the quantitative or qualitative results of the Bessemer process. A sample of the pig-iron is taken and inspected before each charge, and the less gray and graphitic it is found to be, the more charcoal dust is blown into the converter. When this operation is properly regulated and managed, the charcoal dust is burnt in the converter below the surface of the iron, and increases the heat to such an extent that excellent results are obtained from mottled pig-iron. The quantity of charcoal dust used varies from 60 to 200 lbs. in a charge of three tons.

According to a communication, received through the kindness of Mr. Edward Juchelka, at Neuberg, the apparatus used for the purpose consists of an upright wrought-iron cylinder, ending below in a narrow pipe by which it is connected with the main blast-pipe. The connecting pipe is provided with a cock. The required quantity of charcoal dust is put into the cylinder from above. The cock in the connecting pipe being closed, the cylinder is then shut tight at the top by an iron plate, which is screwed on to it. When the blast is let on and the converter is turned up, the cock is opened. The charcoal dust is then blown into the converter together with the air. This is distinctly noticed by the appearance of the flame. When, after some time, the blast ceases to carry charcoal dust into the converter, as it often happens, this is also noticed at once and easily helped. The blast valve is then shut down entirely for a few seconds. The pressure of the blast depending during this time on the pressure in the accumulator only, sinks rapidly from 20 lbs. down to 14 or even to 12 lbs., and when, after this, the valve is reopened, the blast continues to draw charcoal dust from the cylinder. As a general rule the pressure of the blast must be kept pretty high, because with a low pressure the charcoal is not burnt in the converter below the surface of the molten metal, but is carried through unchanged, and burns afterwards uselessly in the stack.

In November and December, 1868, some attempts were made at Neuberg to use graphite instead of charcoal dust, according to the suggestions of Mr. H. Brunner, teacher at the Leoben Mining School. As highly graphitic pig-irons work best in the Bessemer process, Mr. Brunner thought that graphite might be more effective than charcoal when blown through the iron. But this idea is based on the probably erroneous supposition that gray pig-iron, even when in a molten state, contains a considerable amount of carbon in the shape of graphite. However, all the well-known phenomena connected with the chilling of pig-iron, seem to prove that in gray pig-iron, when melted, nearly all the carbon is combined or dissolved, and that it is not present then in the shape of a solid graphite. When gray pig-iron is melted and poured into cold water, it appears white, because sufficient time is not left for the carbon to separate from the iron and to crystallize as graphite. The iron is then retained in about the same molecular condition and construction which it had in its fluid state.

A report on the experiments made with graphite, by Mr. J. Schmiedhammer, the chief engineer and technical manager of the Neuberg works, is published in "Oestr. Zeitschrift," 1869, No. 23. This report is the more interesting, as it compares the results obtained with graphite with those obtained by the use of charcoal dust.

Mr. Schmiedhammer reports as follows: "The experiments were made in the small converter, to get the charges as small as possible. The graphite used was of the best quality, and finely pulverized. In the first charge 50 lbs. of graphite were blown into the converter, that is, about one per cent of the pig-iron. In the three following trial charges, two, three, and four per cent of graphite were used. Immediately after the third, and again after the fourth trial charge with graphite, another charge was made with the same pig-iron, and under the same circumstances, except that charcoal dust was used instead of graphite. The pig-iron was taken from the available stock, and was melted with coke in a cupola furnace. The pigs were carefully selected and of uniform appearance. The iron was mottled and of such a composition that it became white when cast into iron molds.

The results of the six experimental charges (four with graphite and two with charcoal dust) are contained in the following table:

In comparing the results contained in the above table we are led to the following conclusions: Graphite, when blown into the converter, does not remedy to a lack of carbon in the pig-iron. The graphite seems to burn but incompletely, if it burns at all. This fact is also indicated by the flame, which has a more or less dull and cloudy appearance in proportion as graphite is used.

Graphite does not lengthen the first period of the process. This is, however, done by the charcoal dust, the use of which therefore counteracts the disposition of mottled pig-iron towards producing vehement discharges from the mouth of the vessel.

Graphite is not able to make a charge with mottled iron hot enough, not even when the iron is very hot in being run into the converter.

The product obtained with graphite has all the qualities of a metal resulting from a cold charge. It chills easily, and is short at a yellow heat. The slag is pasty and tough, and not very fluid. Great losses are caused by discharging and sculling.

With graphite the pressure of the blast has to be diminished considerably during the second period, to avoid too copious discharges. This is necessary but to a very small extent when charcoal dust is used.

The charges, Nos. 905 and 950, made with mottled iron and charcoal dust, were as regular and good as if gray iron had been used. The duration of the first period was

Date.	No. of charge.	Pig-iron.			Products.							Percentages.					Duration in Minutes		Graphite or charcoal dust uesd.	Time during which the fuel was blown into the vessel.
		Number.	Run into vessel.	Recarburizer.	Ingots. — Quality. 1st.	2d.	3d.	Scrap.	Scull.	Thrown out of the vessel.	Grade of hardness.	Ingots.	Scrap.	Scull.	Thrown out of the vessel.	Loss.	1st period.	Whole charge.		
Charges with Graphite.																			graphite.	
			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.									lbs.	min.
Nov. 27..	891	7	4,800	240	......	......	3,595	50	75	400	VI w	71.33	.99	1.48	7.93	18.26	5	17½	50	6
Nov. 28..	895	7	4,800	140	......	......	2,375	20	600	900	VII	48.08	.40	12.14	18.21	21.15	4	17	100	4½
Dec. 1..	904	7	4,600	210	......	......	3,830	30	140	200	VII	79.63	.62	2.91	4.15	12.68	6	20	150	7
Dec. 12..	949	7	4,800	290	......	4,010	......	20	70	180	VI	78.78	.39	1.37	3.53	15.91	5	19	200	6
Charges with Charcoal dust.																			charcoal.	
Dec. 1..	905	7	5,050	240	4,720	......	......	20	....	....	VII	89.22	.38	......	......	10.39	14	27	200	12
Dec. 12..	950	7	5,400	290	5,020	......	......	20	....	....	IV	88.22	.35	......	......	11.42	11	22	200	10

In charge 895, a small quantity of pig-iron was used for recarburizing, because the loss of metal from discharging was considerable.

In charges 949 and 950, a large quantity of pig-iron was used for recarburizing, with the intention to produce a harder grade of metal.

normal. The metal proved to be of good quality. The slag was very fluid."

From this report, and from the fact that Mr. Stockher's method is in continual and successful use at Neuberg, we may infer that to work mottled iron by the Bessemer process, fuel is required, and that this fuel must be such as to burn readily with air at a moderate temperature.

Some kind of gaseous fuel, for instance, ordinary illuminating gas, when used with the necessary precautions against explosion, would perhaps make it possible to convert even a white pig-iron to advantage into Bessemer metal. The economy of such a proceeding would depend on local circumstances.

MODERN ORDNANCE.

From the opening address of Sir WILLIAM G. ARMSTRONG before the Institute of Mechanical Engineers, at Newcastle.

When battles were fought hand to hand, war, so far as mechanics are concerned, was an affair of muscular force, and was in that form the most sanguinary, because combats were the most close. When other forces were called into play, inventive appliances became necessary, and these, as they have advanced, have more and more widened the distances separating combatants, and have thus operated to prevent that greater sacrifice of life which would otherwise have resulted from the employment of more destructive weapons. It is, therefore, not to be supposed that future wars will be rendered more murderous by the intervention of the engineer; on the contrary, we may fairly anticipate that the more the element of intelligence supersedes that of animal force in military struggles, the more will the barbarity of war be mitigated. Science naturally sides with civilization, and tends to establish a supremacy over barbarism, and we find this tendency, as in the case of the late Abyssinian war, not only giving overwhelming superiority to the cause of civilization, but deciding the issue with the least possible waste of life. But whatever our sentiments may be in regard to war, it would be absurd to contend that we ought to withhold from invention, when the object sought to be attained is the destruction of life and property. It is our province, as engineers, to make the forces of matter obedient to the will of man, and those who use the means we supply must be responsible for their legitimate application.

It will be in the recollection of the members of this institution who visited the Elswick works on the occasion of the last meeting at Newcastle, that two or three small breech-loading rifled guns were shown to them as novelties deserving their attention. Those guns had then very recently received the recognition of the British Government, and may be regarded as the small beginnings of a system of ordnance which has since attained a very extensive adoption in this and other countries. It was not until the principle of rifling was adopted for military firearms, that these weapons presented much scope for the mechanician's art, but the introduction of rifling, and the change in the form of the projectile from a sphere to a pointed cylinder, brought about a complication of new conditions which it has required years of research and experiment to meet and satisfy. Passing over the subject of rifled small arms, which of late has called forth a great amount of ingenuity and skill, I will speak of artillery, as being that division of gunnery with which I am personally connected.

The most important of all the considerations affecting modern artillery, is how to obtain the strongest possible tube with the least possible weight. Before I state my views as to the best mode of attaining this object, I must call attention to the conditions affecting the force to be resisted. When a charge of powder is fired in a gun, it is converted into gas at an exceedingly high temperature, and the pressure exerted is due, even in a greater degree, to the heat than to the quantity of gas produced. But the heat evolved is not wholly realized in augmentation of pressure, a considerable part of it being absorbed by the material of the gun. The heating of a gun by firing is an effect familiar to every one, and it affords an indication both of the quantity of heat abstracted from useful effect, and also the amazingly high temperature of the gas before it escapes from the gun. Fifty rounds fired in quick succession from a field-piece, will make it so hot that it cannot be touched. Since the flame is only in contact with the bore for about the 150th part of a second at each discharge, it follows that the aggregate duration of the flame contact by which the gun is thus heated in fifty rounds, only amounts to one-third of a second. The thin film of heated matter deposited on the surface of the bore at each discharge, contributes, in some measure, to this rise of temperature ; but we may regard the acquisition of heat from this source as fully neutralized by the cooling of the gun in the intervals occupied by loading. Thus, then, you will be able to appreciate both the intensity of the heat of the gas and the extent of the waste by absorption. In small guns the area of absorbing surface surrounding the charge is greater in relation to the mass of the charge, than it is in larger guns. Therefore, the waste caused by the heating of the gun is also relatively greater, and the gas never attains either the same heat or the same pressure in the smaller weapon as in the larger. But the greater heat attained in a large gun, adds to pressure not only directly, by expanding the gas, but indirectly, by accelerating the combustion of the powder. The powder must be regarded as fuel burning in a furnace, and the hotter the furnace is the quicker the fuel will burn. You will perceive, then, that the pressure of powder-gas per unit of surface is augmented by increasing the size of the gun, apart from all considerations regarding the projectile. But the pressure of the gas is further increased in large rifled guns by the great length of column represented by the projectiles. The resistance increases with the length of the projectile, and the pressure rises with the resistance. Augmentation of pressure is also caused by the rifled projectile having to acquire motion of rotation in addition to that of translation, though the increase of resistance, and of consequent pressure due to this cause, is not so considerable as is commonly supposed. For these various reasons, the introduction of the rifled principle, and the enormous increase of size demanded in modern ordnance, combine to intensify that pressure to a degree which taxes our utmost resources to control. The limit of the pressure actually reached in rifled guns of the largest size, when fired with English service powder, is not yet fully ascertained, but it is probably not less than 70,000 lbs. on the square inch.

Now comes the question of what construction is best adapted to resist so inordinate a strain. It was long since demonstrated by Professor Barlow, that a cylinder, to possess the greatest possible resistance to a bursting force, must, when out of action, have its interior in a state of compression, and its exterior in a state of tension. He further proved it to be necessary that the internal compression should diminish in an outward direction, and the external tension in an inward direction, up to an intermediate zone of neutrality. If these conditions were neglected, he showed that in a very thick cylinder, the material forming the interior portion would be stretched to the breaking point before the exterior portion acquired any considerable tension. The interior, therefore, would be overstrained, while the exterior would be understrained, and the aggregate resistance would necessarily be less than if all parts were doing full duty. This reasoning is the foundation of the argument in favor of built-up guns, in which every layer of the material is stretched upon the layers beneath, and the finished structure is in the condition of internal compression and external tension, demonstrated by Barlow to be that of greatest strength.

The Americans have endeavored, with partial success, to realize the advantage of this principle in cast-iron guns, by cooling the inside first, and allowing the external portion of the metal to shrink upon the hardened interior. The Rodman cast-iron gun is made upon this principle, and considering the nature of its material, has, in some examples at least, exhibited great power of resistance, though not sufficient to enable it to be used for heavy ordnance in the rifled form.

Where forged material is used for the fabrication of guns, this condition of outward tension and inward compression is unattainable except by the application of the material in successive layers, each stretched on those below. Considerations of economy or convenience may supervene to reduce the number of layers, as in the Fraser modification of coil-made guns ; but theoretical perfection will be most nearly reached in that gun which is composed of the greatest number of layers. To attempt to forge large guns in single blocks, is a direct violation of established theory, and the general failure which has attended such attempts, is a practical proof of the truth of the theory.

The next point to consider is the best kind of material for the fabrication of guns. In determining this question, the choice clearly lies between steel and wrought-iron. I say this with no disparagement of Major Palliser's system of adapting cast-iron smoothbore guns for rifling, by introducing a tube of coiled wrought-iron, but this method has, hitherto, only been applied with success to guns which, though formerly classified as heavy ordnance, are dwarfed by comparison with the ponderous guns of the present day.

For these we require the greatest strength we can attain, and cast-iron cannot possibly be regarded as so efficient for enveloping the internal tube as either wrought-iron or steel. In discussing which of these two materials is best, I shall be trespassing on controversial ground. Krupp and Whitworth, both great names in gunnery, though differing widely in their views on other points, agree in this, that steel is the right material for the entire gun. I, on the other hand, have always advocated wrought-iron in the form of welded coil for the chief mass of the gun, limiting the use of steel to the internal tube, which has abrasion to resist as well as tensile strain. The expression of my opinion upon this point may probably not be considered impartial, but I will nevertheless state the grounds upon which my preference of wrought-iron thus applied is based. It has been found both in Elswick and Woolwich guns, that whenever failure takes place, it almost invariably originates with that part which is made of steel. It is the steel tube which is nearly always the first to crack. So, also, when the vent-pieces or closing blocks of the breech-loading guns were made of steel, their fracture was alarmingly frequent, but since wrought-iron has been substituted, such occurrences are rare. The conclusion, therefore, at which I long since arrived, and which I still maintain, is that, although steel has much greater tensile strength than wrought-iron, it is less adapted to resist concussive strain.

This conclusion is in strict harmony with the fact that armor-plates made of steel have proved on every occasion of their trial, greatly inferior to plates of wrought-iron. The experiments which I made some years ago on the toughening of steel in large masses, by immersion, when heated, in oil, led me to expect that this fragility would be obviated by that process, and I felt sanguine that I should be able by such treatment to produce steel armor-plates of extraordinary resisting power. An armor-plate of steel was accordingly manufactured for experiment, and was tempered in a large bath of oil. Its quality was tried by test pieces cut off after tempering, and proved by tension and bending. The results showed a very high tensile strength, combined with so much toughness, that I was unable to match its bending power by any sample of iron I could compare with it. The plate was then sent to Portsmouth for trial, in the fullest confidence of its success, but two shots from a 68-pounder sufficed to break it in various directions, and it was justly pronounced a failure.

With these experiences before me, it is impossible that I can hold any other opinion than that the vibratory action attending excessive concussion is more dangerous to steel than iron, and were it not necessary to provide a harder and more homogeneous substance than wrought-iron for the surface of the bore, I should entirely discard the use of steel for the manufacture of ordnance. I do not mean to contend that very strong guns may not be made of steel, but I am convinced that failures will be more frequent, and, I may add, more disastrous, with steel than with iron, when the conditions of trial are the same. The want of uniformity in the quality of steel, continues to be another serious objection to its use; and, in addition to all these considerations, the element of cost is greatly in favor of the wrought-iron coil construction over every mode of manufacture in steel.

I will now offer a few remarks upon the interesting question of the probable future of guns. Upon the solution of this question depends the pattern of future ships, and also the policy of continuing or abandoning the struggle of armor-plates against guns. From my previous remarks on the increase of pressure with which we have had to contend as we have increased the size of our guns, it might be inferred that we were now nearly reaching a limit, beyond which the strength and endurance of our material would not enable us to pass. I am not prepared to say how far we could have advanced under the recently existing conditions; but certainly every increase of size would have been attended with increase of difficulty.

A new light, however, has just dawned upon the subject, which entirely alters the prospect. It has become apparent that the power which we have been using can be so modified as to produce the required effect, with greatly less strain upon the gun. It may appear paradoxical that there should be a limit to the theoretical advantage of increasing the initial pressure of the gas evolved in the gun, but the apparent anomaly will disappear on examination. The action of expanding gas in a gun is analogous to that of expanding steam in the cylinder of a steam engine, and we all know the advantage, in the case of steam, of having a high pressure to begin with, provided a steam jacket be used to maintain the material of the cylinder at a temperature equal to that of the entering steam. But in a gun we can have no provision analogous to the steam jacket, and it would appear that it is owing to the necessary absence of such a provision that there is a limit to the increase of initial pressure, beyond which no gain of propelling force is realized.

Perhaps I shall not be fully understood without explaining this curious and important subject in a more definite manner, and I will therefore endeavor to do so. The force exerted in a gun bears a certain relation to the heat evolved by the gasification of the charge. The greater the heat the greater the force, for heat is nothing more than unexpended force. I have already alluded to the loss of heat by transmission to the gun, and it is evident that this transmission must be greatest in amount when the heat of the gas is highest. By using a slower burning powder, less heat and pressure are evolved at first, and the waste of heat in the stage of initial pressure being less, more heat remains for expansive action. Hence the slower burning powder is weaker at first, but stronger afterwards, and although the total quantity of gas be only the same, and the pressure not so great at any point, yet the aggregate pressure throughout the bore may equal that of the more energetic and more dangerous powder. This would not be so if the gun, like the steam-jacketed cylinder, could be maintained at the maximum temperature of the elastic medium within. But in the case of the gun, that temperature would be far above the melting point of its own material.

It is only lately that attention has been strongly directed to the powder question in England. In Russia and Prussia, where great efforts have been made to obtain endurance with large rifled guns, powder similar in granulated form to that used in England, has long been wholly discarded and superseded by powder stamped into prismatic blocks, which burn more slowly; but although we have erred in using a powder for our new ordnance, so violent as to be justly designated "brutal," by the French, yet we have this satisfaction, that the ordeal which our guns have sustained with our severer powder, affords an assurance of strength which we could not have had if they had only withstood the mild description of powder with which alone continental guns have been successfully tried. Attention is now fully awakened to the subject, and a scientific military committee is conducting experiments upon the force of different descriptions of powder.

In these experiments the pressures exerted in every part of the gun are determined, by the use of an instrument of exquisite delicacy, invented by my friend and partner, Captain Noble. This instrument, which is a happy combination of mechanical and electrical action, indicates the velocity attained by the projectile at any number of points in the gun, and from these velocities the pressures are deduced by calculation. Thus a diagram of pressure can now be exhibited for gas in a gun, as well as for steam in a cylinder, and I think you will agree with me in regarding this result as no small triumph of mechanical science. The mitigation of initial pressure, which is now known to be compatible with the maintenance of efficiency, opens a new future for guns, and removes all doubt as to the practicability of increasing their size and power to an extent which it would be vain to follow on the side of the defense by increase in the thickness of armor.

No present armor-clad vessel is proof against present guns, and there is not the slightest probability that future armor will be proof against future guns. Ships of the Warrior class can already be pierced with shot or shell, fixed at considerable ranges, by even second-class guns, and the still stronger ships, now in course of construction, are pretty sure to be similarly overtaken in a very few years. Unless armor be invulnerable, it is of very doubtful advantage as a defense. It will, perhaps, prevent the entrance of shells, containing large bursting charges, but on the other hand the passage of a shot through the thick side of an armor-clad, carries with it a mass of fragments that would act with terrible effect upon the crew. If we cannot stop a shot, the next best thing is to facilitate its passage through.

Wooden ships are out of the question, because they are combustible, but we may have ships of iron without the armor. Whatever weight we carry as armor, we lose as armament, and if we lessen the offensive power of a ship, by loading her with armor, we ought to be very sure that the armor will realize its defensive purpose.

The efficiency of modern ordnance against armor-plate is dependent, not only on the power of the gun, but also upon the material and form of the projectile. Ordinary cast iron proved absolutely useless for projectiles to be used against thick armorplates, and until Major Palliser applied the process of chilling to the manufacture of cast-iron projectiles, there was every reason to believe that hardened steel was the only material that could be used for this purpose with effect. The process of chilling gives extreme hardness to cast-iron, but, in point of toughness, a chilled cast-iron shot is inferior to one of steel. Steel, however, though much less liable to break, is more easily crushed; and this brings me to notice a curious evidence of difference in the amount of the penetrative power lost by crushing and by breaking. A crushed projectile is always much less heated by the blow, but the fragments of a chilled projectile remain cool. Hence, we see that crushing detracts more from the power of a projectile than breaking, because the heat developed in a projectile by striking a plate, is a criterion of the amount of force expended upon the projectile, instead of the plate. We accordingly find that a Palliser shot breaking by impact, will nevertheless pierce more easily than a steel shot which remains whole, but yields to crushing.

As to the proper form of head to be given to the projectile for piercing armor, you will remember that a few years ago this question was hotly contested between the supporters of round heads and flat heads; but, as often happens in the case of human contentions, not limited to the sphere of mechanical engineering, both parties were afterwards proved to be wrong. When Major Palliser brought forward his chilled projectile, he advocated a pointed head, and with the new material he was found to be right. Major Palliser has competitors on the Continent, whose claims I cannot pretend to weigh, but in this country, at all events, he is entitled to the honor of improving both the material and the form of the projectile, thereby greatly increasing the penetrative power of our artillery, and, at the same time, effecting an enormous economy in the manufacture of projectiles.

The most legitimate use of instruments of war is for the purpose of home defense, and I, therefore, proceed with satisfaction to notice a class of inexpensive vessels requiring no armor, and adapted to render the heaviest artillery available for the protection of our shores and harbors. Until very recently, there seems to have been an impression that large guns required large vessels to carry them; but the fallacy of this idea has been practically shown by the proving barge of the Elswick works, which is a mere floating gun carriage. This little vessel, which is only sixty tons burden, is continually used, without difficulty, for the trial of twelve ton guns at sea, even when the swell is considerable. This proving barge was the origin of Mr. Rendell's idea of the now well known gunboat Staunch.* The Elswick barge has no steam power, and thus represents the minimum of size; but the Staunch is provided with steam power, both for propulsion by means of twin screws, and for working her twelve-ton gun. She is, therefore, somewhat larger than the Elswick barge, and yet so small as to be very inexpensive, and at the same time a very difficult mark to hit. To burden such a vessel with armor, would at once increase her size and her cost, thus rendering her more easy to hit, and more expensive to lose. A simple screen might, perhaps, be advantageously applied as a protection against shrapnel; but thick armor, if used at all, should be reserved for ocean ships. I have so recently published my views on the subject of this vessel, that I need not now repeat them further, merely observing that guns of the largest size now made, or ever likely to be made, may be mounted in vessels similar to the Staunch, without increasing their tonnage in more than a proportionate degree.

Another recent invention, highly favorable to defense, is the celebrated gun carriage of Captain Moncrieff. By the ingenious arrangement of the carriage, the recoil of the gun operates in a downward direction, and in descending it lifts a counterweight, which, when liberated, after loading, raises the gun again to the height necessary for firing over the edge of a parapet. By this mechanism, the gun is handled with almost perfect security to the men, and is itself exposed in the smallest possible degree, and only for a few seconds while being fired. No embrasures being required, the gun is not restricted in lateral range. This is the characteristic advantage of the barbette system of mounting guns, which has, however, the fatal objection of exposing both guns and gunners. Embrasures are always a source of trouble in fortifications. They not only

* The idea of floating, self-propelling gun carriages, was original with the late Edwin A. Stevens, one of the projectors of the "Stevens Battery," and the first practice in this direction was that of the Stevens gun boat "Naugatuck," during the late war.—Ed.

admit but guide projectiles into the fort at the very points where guns are placed. In iron defenses, the opening for the gun is even more objectionable. Not only does it weaken the whole structure, but it serves to break up cast-iron shot striking on the edge, and thus to occasion terrible destruction inside. I may state as a fact, communicated to me by a Brazilian officer, on whose testimony I rely implicitly, that in the late Paraguayan war, in which he was engaged, he saw whole gun crews swept away in the Brazilian iron-clads, by common cast-iron round shot, contemptible for piercing even the weakest armor, but which, striking the edge of the port, entered the ship in a torrent of fragments. The Moncrieff gun carriage gives great additional value to earthworks, and, in fact, may be used in mere pits which would be wholly invisible to an enemy. It would probably also prove to be available in combination with iron defenses, as a means of avoiding the objection of port-holes, and it will have the effect of placing muzzle-loading guns on a par with breech-loaders in regard to security and ease of loading. Captain Moncrieff's invention will play a very important part in defensive operations, and will greatly reduce the expense of fortifications.

Many other instances may be cited in illustration of the tendency of mechanical progress to favor defense. Thus the increasing size of guns renders them difficult to transport for offensive use abroad, but creates no impediment to their defensive application at home. Or, if we look to the nautical side of the subject, we see that the conditions sought to be attained in war-ships for aggressive action involve enormous cost, and that the great size of these vessels makes them favorable targets for the fire of opposing artillery. On the other hand, the vessels required for coast and harbor defense are of cheap construction, and their small size and facility of movement give them the advantage of being difficult to hit. The Moncrieff carriage is applicable almost exclusively to defensive purposes; and the same may be said of torpedoes, which, by many ingenious contrivances, have recently been rendered most formidable obstacles to naval attacks upon seaports. The tendency, therefore, of mechanical invention, as applied to war, is to discourage aggression, and thus to maintain peace. We may, consequently, hope that it will hasten the arrival of a period when civilized nations will abandon the arbitrament of arms, and settle their differences by rational and peaceable methods. But, while I defend the mechanical branch of military science from all imputation of serving the cause of war, I do not forget that it is to the civil branch of mechanical engineering that the honor of promoting the friendship of nations especially belongs. It is by the facilities it gives to intercourse and exchange, and by the reciprocal benefits which flow therefrom, that it teaches men how much they have to gain by peace and lose by war.

The Avondale Disaster.—We have in this country long been spared the frequent and ghastly disasters that characterize British mining. Even the few catastrophies that have occurred here, are attributable to carelessness and neglect rather than to the presence of noxious and inflammable gases. It would appear that human ingenuity could hardly have devised a more certain man-trap than the Avondale mine. But whatever the causes of these terrible sacrifices may be, *mining by machinery* will now begin to have the significance and attention here that it is receiving abroad. The breaking down, moving and manipulating of coal by inanimate power, with only the supervision of a few men, will at once and greatly decrease the risks to human life and the cost of getting coal—and humanity has little to hope for if economy and safety do not go hand in hand.

THE ELLERSHAUSEN PROCESS.

We publish, herewith, a table of the results of several single heats made by this process at the Bessemer Steel Works, Troy, and also the results of five weeks' continuous working at the establishment of Messrs. Shoenberger & Co., at Pittsburg.

The mixing of the ore with the melted pig-iron, in the Troy experiment, was thorough, and the subsequent operations in the puddling furnace were very carefully performed. The results, however, are not uniform, and do not, as a rule, show the improvement in the quality of the product observed elsewhere. It is now evident that the Troy experiments were not sufficiently extended to give a fair average result. It appears from these experiments that some irons are better adapted to this process than others; also that the ore from which the pig-iron is made is not the best ore to mix with the same pig-iron, to convert it into a pig-bloom.

Experiments made by the Ellershausen Process, at the Bessemer Steel Works and at the Rensselaer Iron Works, Troy, N. Y., April, 1869.

Kind of Pig.	Kind of Ore.	Percentage of ore to 100 lbs. pig. Ellershausen.	Weight charged in furnace.	Yield.	Loss in lbs.	Per cent of loss of product. Ellershausen.	Per cent of loss of product in ordinary puddling.	Per cent of ore used in fettling Ellershausen.	Per cent of fine ore on yield. Ellershausen.	Total per cent on product of ore used. Ellershausen.	Total per cent on product of ore in ordinary puddling.	Average time per heat Ellershausen. h. m.
Fort Edward No. 3.......	No. 21 Port Henry....	24.9	4,615	3,710	905	19.61	......	45	30.98	75.98	45	1 30
do	No. 21 do	33.	4,875	3,610	1,265	25.95	......	45	44.56	89.56	......	1 30
do	No. 21 do	25.1	4,760	3,910	850	19 95	......	45	30.56	75.56	......	1 30
Clove No. 1. I..........	No. 21 do	24.9	4,740	3,360	1,380	29.11	5.30	90	35.42	125.42	60	2 30
do No. 1. II..........	Dakin hematite.......	14.3	4,765	3,555	1,210	25.40	......	90	19.17	109.17	......	2 30
do No. 1. III..........	No. 21 Port Henry....	30.7	4,585	3,220	1,365	29.77	......	90	43.71	133.71	......	2 30
R. I. W. Mixture, ⅝ Hudson No. 2, ⅜ Fort Edward No. 3.	No 21 do	32.5	5,123	3,880	1,243	24.26	2.22	45	42.91	87.91	45	1 30
R. I. W. Mixture.........	No. 21 P. H. 90 per ct. Oxide manganese 10 pr cent................	22.4	4,995	3,845	1,150	23.02	......	45	28.82	73.82	......	1 30
Puddled by Ordinary Process.												
Clove No. 1.............	....	......	1,320	1,250	70	5.30	5.30	60	......	......	60	
Fort Edward No. 3.	....	......	2,700	2,730	gain 30	......	......	45	......	......	45	
R. I. W. Mixture.........	....	......	2,700	2,670	loss 30	......	2.22	45	......	......	45	

Experiments mnde by the Ellershausen Process, etc.—Continued.

Kind of Pig.	Kind of Ore.	Average time per heat puddling. h m.	Reheated. Charged, lbs.	Reheated. Yield, lbs.	Reheated. Loss, lbs.	Reheated. Per cent of loss.	Appearance of Fracture of Bars made by cutting up puddle-bars and re-heating them once.
Fort Edward No. 3.........	No. 21 Port Henry.......	......	760	710	50	6.58	Fracture nearly all granular and rather cold short; not red short
do	No. 21 do	......	750	685	65	8.67	Fracture granular and cold short; not red short.
do	No. 21 do	......	790	750	40	5.06	Fracture granular and quite cold short; not red short
Clove No. 1. I............	No. 21 do	......	745	700	45	6.04	Fiber close and silky; very tough; very slightly red short.
do No. 1. II............	Dakin hematite..........	......	760	700	60	7.90	Granular and fibrous streaks; rather cold short, but not red short.
do No. 1. III............	No. 21 Port Henry.......	......	735	675	60	8.16	Granular and fibrous streaks; rather cold short, but not red short.
R. I. W. Mixture, ⅝ Hudson No. 2, ⅜ Fort Edward No. 3.	No. 21 do	......	....	.....	.....	....	Fibrous and silky fracture; very tough; much better than the same puddled; not red short.
R. I. W. Mixture..........	No. 21 P. H., 90 per cent. Oxide manganese 10 per cent....................	......	....	.....	.....	....	Fiber more close and silky than the above; very fine and tough; not red short.
Puddled by Ordinary Process.							
Clove No. 1................	....	1 30	690	635	55	7.97	Entirely fibrous and silky; neither cold short nor red short.
Fort Edward No. 3.........	....	1 20	730	670	60	8.22	Fracture partly granular; fibrous part quite silky; slightly cold short; not red short.
R. I. W. Mixture..........	....	1 20	755	700	55	7.28	Granulated with streaks of fiber; cold short; a little red short.

Analyses of some of the Materials and Products in the Troy Experiment.

	Clove pig.	Clove puddle bar.	Cove III, Ellersh'n bar.
Total carbon	3.75	1.158	.34
Combined silicon	4.15	.298	.026
Phosphorus	.38	.273	.29
Sulphur	.09	none.	.0034
	Fort Edward No. 3, pig.	Fort Edward puddle bar.	Fort Edward Ellers. bar.
Total carbon	4.17	.38	.197
Combined silicon	1.54	.04	.261
Phosphorus	.93	.28	.480
Sulphur	.016	.0096	none.

Dakin Hematite Ore.

Sesquioxide of iron	62.94
Protoxide of manganese	.40
Silica	26.32
Water	10.65

Port Henry No. 21 Ore—Magnetite.

Sesquioxide of iron	60.39
Protoxide of iron	27.06
Titanic acid	1.30
Silicic acid	5.38
Magnesia	2.36
Alumina	2.80

The results of five weeks' working at Messrs. Shoenberger & Co.'s, are based on the amount of ore used in the blast-furnace, also the amount of pig metal and of pig-bloom (conglomorate of ore and partially decarburized pig-iron, as obtained by the Ellershausen process), and the average loss on the pig bloom.

During this time all the cinder from the Ellershausen process was used in another blast-furnace where they were making white iron for a rail mill in Chicago.

Ore used.		lbs.
Mannora	at 50 per cent,	2,286,502
Iron Mountain	at 66 "	1,299,789
Sterling	at 50 "	613,307
Lake Superior	at 62 "	498,882
Containing iron		2.617,540

Iron produced.	lbs.
Pig metal	739,200
Pig bloom	2,452,800
	3,192,000

Loss on pig bloom in furnace 24 per cent (average), the bloom containing, according to the calculation of Messrs. Shoenberger & Co., about 27 per cent of ore (Lake Champlain).

Supposing even that the pig metal, if worked into the Ellershausen bloom, had yielded only its own weight in muck-bar, instead of gaining 3 per cent, then we have

	lbs.
Iron from pig metal	739,200
" pig bloom	1,849,600
Total amount of iron	2,588,800

This would show only a loss of a little above one per cent over the amount of iron contained in the ore as found by analyses.

The loss in puddling their pig, Messrs. Shoenberger have found to average 8 per cent.

It is a fact that Messrs. Shoenberger & Co. have not heretofore been able to make horse-shoes from their own puddled iron, but were always compelled to buy good scrap iron. Now they are making all their horse-shoes from the Ellershausen iron, the *horse-shoe billet* being rolled directly from the muck-bar.

The following data relating to the Ellershausen process are from Messrs. Shoenberger & Co.'s books:

In *the puddling process* the production of a single puddling furnace is about 2,600 lbs. per day.

To fix the bed of furnace takes from 100 to 150 lbs. of scrap iron.

To fix the bed of furnace takes from 200 lbs. of ore.

In the *Ellershausen process* the production per day, in single furnace, is 4,000 lbs.

To fix the furnace-bed they have used only 50 lbs. of ore per day, and *no scrap.*

Working in a large furnace—three men to the furnace—the yield per shift has been for months 6,300 lbs., consuming only 70 bushels of bituminous coal, while in puddling they use 47 bushels of coal per ton of muck-bar.

Table of Analyses.

1 Pig metal from Messrs. Shoenberger & Co., gray.
2. Pig metal from Messrs. Shoenberger & Co., white (only with reference to sulphur—was made from ore containing considerable am't of pyrites.
3. Slag from puddling process.
4. Slag from Ellershausen process.
5. Muck-bar puddled iron.
6. Muck-bar Ellershausen iron.
7. Muck-bar puddled iron.
8. Muck-bar Ellershausen iron.

	1.	2.	3.	4.	5.	6.	7.	8.
Carbon chem. comb.	2.87	....	....	....	} .43	.39		
Graphite	1.34	....	....	....				
Silicium	1.02	....	....	....	.20	.09		
Sulphur	.14	.42	....	....	.011	.006	.027	.012
Phosphorus	.58	....	....	....	.12	.14		
Iron	92.46							
Silicic acid	....	....	14.02	8.95				
Peroxide of iron	....	....	17.71	16.01				
Protoxide of iron	....	....	60.31	68.88				
Lime	....	....	2.08	1.74				
Magnesia	....	....	.84	.85				
Alumina	....	....	1.44	1.31				
Phosphoric acid	....	....	2.54	1.74				
Sulphuret of iron	....	....	.88	.72				

Copper, cobalt, aluminum, calcium and slag not determined.

Analysis of Pig Metal and Muck-bar for Messrs. Shoenberger & Co.

a. Pig metal from Sligo furnace (gray).
b. Pig metal from Sligo furnace (white).
c. Pig metal from Penn. furnace (gray).
d. Pig metal from Penn. furnace (white).
e. Muck-bar from Sligo iron, puddled.
f. Muck-bar from Sligo iron, Ellershausen process.
g. Muck-bar from Penn. furnace, puddled.
h. Muck-bar from Penn. furnace, Ellershausen process.

	a.	*b.*	*c.*	*d.*
Iron	93.01	93.40	94.45	
Manganese	.21	.41	trace.	
Silicium	.93	.28	.41	.31
Phosphorus	.59	.65	.22	.19
Sulphur	.03	.03	.009	trace.
Carbon combined	1.05	4.81	1.34	4.74
Graphite	3.86	.21	3.18	.24
Slag	.34	.21	.40	.31

	e.	*f.*	*g.*	*h.*
Carbon	.34	.29	.31	.24
Silicium	.17	.16	.07	.05
Phosphorus	.25	.22	.16	.15
Sulphur	trace.	....	none.	none.

The ore used for mixing in the Ellershausen process was a brown hematite, containing .21 phosphoric acid, 63.00 peroxide of iron, 13.00 water, balance almost exclusively silica and alumina.

In the iron of Lyon, Shorb & Co., from cold blast charcoal iron, there is no perceptible difference between the puddled and the Ellershausen iron, as far as the analysis goes. Mr. William M. Lyon considers the Ellershausen iron supperior to the puddled iron when brought to practical test.

In the experiments of Messrs. Shoenberger & Co., it has been shown that the sulphur is far more thoroughly eliminated by the Ellershausen than by the puddling process.

We shall give, in a future number, the results of the Ellershausen process as tried on a still larger scale, during several months regular working.

PILE-DRIVING BY GUNPOWDER.

From "Engineering."

Considerable attention has lately been paid in America to the ingenious method of driving piles by the explosion of gunpowder recently introduced by Mr. Thomas Shaw, of Philadelphia, and we think that Mr. Shaw's system is likely to be regarded with equal interest on this side of the Atlantic. Mr. Shaw's "gunpowder pile-driver" as it has been named, consists merely of an ordinary pile-driving engine, having a ram provided with two plungers projecting, the one from its upper, and the other from its lower end, and fitted, moreover, with an arrangement for retaining the ram at any desired height. On the top of the pile to be driven is placed a casting, or cylinder, hollowed on the under side to fit the head of the pile, and having bored from its upper side a hole, into which the lower plunger of the ram fits. In this hole is placed a small charge of gunpowder, and the ram, having been raised a few feet, is let fall, when the lower plunger, entering the hole in the cap-piece, compresses and heats the air, which ignites the powder, thus causing the ram to be thrown up again, ready for another blow, and the cap-piece with the pile to be forced downwards.

The plunger at the top of the ram is for the purpose of entering into an air cylinder at the top of the frame, and thus forming an air buffer in the event of the ram being thrown up too high. This upper air cylinder is also useful when there is but little space available for striking a blow, as, in such cases, by hauling up the ram until the upper plunger is forced into the air cylinder, the downward stroke of the ram is accelerated.

So far the action of the apparatus is simple enough, and will be readily understood; but the results obtained with it are difficult to account for satisfactorily. Inasmuch as in regular working the ram is thrown up again to its starting point, it is evident that any work given out by it during its downward stroke must be re-absorbed by it during its upward stroke, and, therefore, that none of the work generated by the fall of the ram can be considered to be available for driving the pile. This driving action must therefore be performed by the power generated by the explosion of the powder, and it is the amount of effective work thus done by the powder which appears to us to be the most remarkable point in the whole affair. Thus, in the case of a model apparatus, lately exhibited by Mr. Shaw at a meeting of the Franklin Institute, the ram, with its plungers, weighed 73 lbs., and had a fall of 20 ft. When no powder was used, a pile, placed under this ram, was driven $\frac{1}{4}$ in. at each blow; but when a charge of 14 grains of white gunpowder (composed of chlorate of potash, ferrocyanide of potassium, and sugar) was employed, the distance which the pile was driven at each stroke was augmented to 2 in., or eight times its former amount. Now, if in this case we were to consider the power expended upon the pile to be in proportion to the distance which the latter is driven, we shall have the explosion of 14 grains of powder generating $73 \times 20 \times 8 = 11{,}680$ foot-pounds of work, or, as 14 grains are equal to $\frac{1}{500}$ lbs., there would be $11{,}680 \times 500 = 5{,}840{,}000$ ft.-lbs. of work developed by the explosion of 1 lb. of powder! Inasmuch, however, as a pound of ordinary powder, burnt in a gun, only developes, on an average, about 180,000 foot-pounds of work, we cannot think—even allowing for the white gunpowder being more powerful than the ordinary kind—that the power developed by the explosion of the powder in Mr. Shaw's pile-driver is anything like that above mentioned; and we are, therefore, led to believe that the efficiency of the apparatus lies more in the peculiar character of the thrust transferred to the pile than to any vast amount of power generated. In other words, it appears to us that in the gunpowder pile-driver a greater proportion of the driving power is turned to useful account than when the ordinary falling monkey is used, and this view of the case is borne out by the fact that with Mr. Shaw's apparatus no injury is done to the head of the pile itself. In the case we have just been considering, the ram was a light one, and its fall great, and these circumstances may at first sight appear to have contributed to the great comparative success of the apparatus when used with powder; but a reference to the report of Mr. Shaw's pile-driver, recently made by Chief-Engineer W. W. W. Wood, U. S. N., will show that, even with a heavy ram and short stroke, the advantages gained by the use of the gunpowder were equally great.

That Mr. Shaw's apparatus forms a very efficient pile-driving engine, Capt. Wood's report, and other information which we have received from reliable private sources, leave us no reason to doubt; whether, however, it is an economical one we have as yet not sufficient data to enable us to determine. In Captain Wood's report, the quantity of powder used is unfortunately not given, neither does the report afford any information concerning the number of men required to work the machine when in regular action. It must be remembered that in a well-arranged steam pile-driver the engine not only serves for working the ram, but also for lifting the piles into place, traversing the machine as required, and doing other work which, if it is to be done economically, must be performed by steam power in the case of Mr. Shaw's pile-driver also; and the question then arises whether, if an engine and boiler have to be provided, it is not better to employ them for doing all the work that has to be done. As regards the comparative cost of developing power by the combustion of coal under a steam boiler, and by the explosion of gunpowder, there can be little difference of opinion, as a pound of coal burnt under the boiler of a steam pile-driver will, on an average, allowing for all losses, produce about the same number of foot-pounds of effective work as a pound of ordinary gunpowder burnt in the chamber of a piece of ordnance, while the cost of the coal will in most cases only be about one-fiftieth of that of the powder. Even supposing the powder to have the vastly increased efficiency estimated from the experiments at the Franklin Institute above mentioned, the cost of generating a certain number of foot-pounds of work would still be in favor of the coal, and it remains to be proved whether in actual working Mr. Shaw's apparatus gives, from its handiness and rapidity of action, results which compensate for this increased cost of generating the power.

Whether Mr. Shaw's gunpowder pile-driver will be able to compete successfully with steam pile-drivers or not, it will undoubtedly render important services in situations where hand-worked machines have hitherto only been available; and in any case its action is in many respects so peculiar, that we feel sure that its further trials will be watched with interest by all who have had their attention directed to this subject.

ICE-MACHINES AND REFRIGERATORS.

From "The Engineering & Mining Journal."

For a century or more the great problem of converting heat into power was being solved, or, in other words, the steam-engine was being brought into existence. It advanced through various stages, and appears now to have attained, perhaps if not its full growth, at least a very high degree of development. At present another problem is being solved—namely, to convert power into cold; in other words, to construct machines to make ice, or produce cooling by means of the application of power; and as the cheapest power we possess is steam power, this is almost exclusively used, when we have the problem to produce cold by mechanical means.

The production of heat by mechanical means is very ancient. From time immemorial, the friction of two rubbing surfaces, such as a grooved board and a stick, has been used by savage races to produce fire; and the heating of the axle-trees of wagons and machinery by friction was observed centuries ago. Comparatively speaking, the practice and successful application of these phenomena have been carried out only recently. In a few factories in Germany, where there was a surplus of water-power, an arrangement was made for producing friction between two cast-iron surfaces, which became heated to such a degree that enough caloric was produced to perform the function of a heating apparatus for various rooms; while Beaumont, in 1856, constructed a heating arrangement driven by power, where the heat was produced by the friction of a very elongated cone of soft meterial, well oiled, and which was placed in a hollow metallic cone,* in which it fitted exactly. Upon being rapidly revolved, a perfectly noiseless friction was the result, producing the full equivalent of heat, as determined by Meyer, Joule, Grove, etc., and to which we have often referred before, namely: one unit of heat for every 772 foot-pounds power employed. The specific heat of one pound of water, being nearly equal to that of 50 cubic feet of air, every 772 foot-pounds will heat 50 cubic feet of air 1 deg., and 120×772, or 92,600 foot-pounds, will heat 120×50, or 6,000 cubic feet of air, 1 deg. If we spend this power every minute, we will have nearly 3-horse-power, as each horse-power is 33,000 foot-pounds per minute. Three horse-power properly employed will therefore heat a space of 6,000 cubic feet (the contents of a common passenger railroad-car) 1 deg. every minute. But as three-horse power cannot be obtained from a locomotive, by a consumption of coal of less than 30 lbs. per hour, it is seen at once that it would not be an economic operation, as so slight a calorific effect may be easily obtained from a common stove, with a consumption of less than one-tenth the above, two to three pounds of coal per hour; which is the average amount burnt in a stove of moderate size, and heats a room of the above dimensions sufficiently, even in the coldest season.

One of the most remarkable facts in connection with the transformation of power into heat, is the perfect uniformity of result, whatever be the means employed to accomplish this transformation. It may be friction of solids, of solids on liquids or gases, through agitating them by means of fan-wheels or other means, compression of gases, magnetic attractions, or by retarding revolving wheels. In short, there may be any means whatever employed to retard or destroy power or motion, we will always have the uniform result; that for every 772 foot-pounds apparently destroyed, one unit of heat will have been obtained—the only condition being precaution not to lose part of the heat thus obtained, nor to consume part

* For description of this apparatus, see *Génie Industriel*, Paris, 1856, page 18.

of the power employed in some other manner. By observing these conditions, different experimenters, employing a variety of means, have obtained such uniform results, that the number obtained, 772, representing the equivalent of heat and power, is one of the most securely established in the whole field of physical sciences.

When converting heat into power, by means of the steam-engine, the results are quite different, and the most enormous discrepancies appear, one machine producing nearly 110 foot-pounds per unit of heat, another 70, another 50, and another only 35 or 40—these numbers being respectively about 1-7th, 10th, 15th, and 20th of 772. It is thus seen that steam-engines produce only small portions of the theoretical amount, and are subject to a loss, ranging from 86 to 95 per cent of what we are some day entitled to expect.*

Referring to the subject mentioned in the opening of this article, the conversion of power into cold, the following question naturally presents itself: Is this conversion practically accomplished without great loss, and with tolerably uniform results, as in the case of the conversion of power into heat? Or is it subjected to the great loss of 86 to 95 per cent, as is the case where heat is converted into power by the intervention of the steam-engine? In answer to this question, we will state that in this case there is fortunately no such loss; when converting power into negative heat, we are able to abstract with a good ice-machine a unit of heat for every 772 foot-pounds of power employed; or 170 units for 170×772, or nearly 132,000 foot-pounds. If we expend the last number of foot-pounds per minute, we spend four-horse powers, and therefore theoretically four-horse power must produce a cooling effect of 170 units of heat per minute. As one pound of water of 62 degrees requires 30 degrees cooling to bring it to 32 degrees, and the abstraction of 140 units of latent heat, 170 units of heat abstracted from one pound of water at 62 degress will change it into ice of 32 degrees; and thus an expenditure of four-horse power must be able to freeze every minute one pound of water of 62 degrees—that is, sixty pounds per hour; and 40-horse power will freeze 600 pounds per hour, or 6,000 pounds per day of ten working hours.

This estimate, which gives the maximum amount of ice which can be produced by a given power, shows at the same time that the reason why artificially obtained ice can compete with natural ice, is, that steam power is so cheap. It has been suggested to make small machines, in which, by the labor of a man, ice, or at least cooling, could be produced, and such machines have actually been made, but only with doubtful success. This becomes clear when we consider that one-man power being only the 32d part of four-horse power, one man could freeze only the 32d part of a pound of water, one-half ounce per minute, or one pound in 32 minutes; this would be the maximum attainable, and that by hard labor, the most perfect arrangement, precaution against loss of power, absorption of heat, etc., all more difficult to obtain on a small than on a large scale. We are compelled to come to the conclusion that the system of refrigeration by means of power is only applicable on a large scale where steam or water power is available. To use the labor of a man to produce cooling by this system, is more expensive, as would be that of animals, in comparison to the employment of steam or water power.

If we estimate the amount of coal necessary to produce the result calculated above—namely, the production of 6,000 lbs. of ice per day by a steam-engine of 40-horse power—we find that, as a horse-power requires in an economical stationary boiler and engine 20 pounds of coal per hour, the 40-horse power will consume per day of 10 working hours 800 pounds of coal. The consumption of this 800 pounds of coal producing 6,000 pounds of ice, gives $7\frac{1}{2}$ pounds of ice for every pound of coal, or $7\frac{1}{2}$ tons of ice for every ton of coal on the supposition that each horse-power consumes two pounds of coal per hour. As, however, in the most economical boilers, a horse-power may be produced by the consumption of less coal, it is clear that it becomes possible to obtain more ice per ton of coal, which quantity can be further increased by future improvements in the steam-engine.

Having thus estimated what we may expect theoretically, let us investigate in how far the practical results obtained agree with these estimates.

In the first ice-machines, built on this principle, some ten years ago, one or two tons of ice were obtained by the use of one ton of coal, and it was at that time considered a great attainment that actually more ice was

* Readers desirous for details in this matter, are referred to the "Journal of Mining" for 1869.

turned out than coal consumed. Very soon it was claimed that, by means of the *ether-machine*, three tons of ice were daily produced by the consumption of seven tons of coal per week; then the ammonia-machine made four to six tons of ice for every ton of coal, which production was gradually increased to eight and ten tons, while lately twelve tons have been claimed for every ton of coal consumed. An ice-machine made by Liebe, and used in England for cooling purposes in a large brewery, produced a cooling effect, which formerly, by means of ice, could only be obtained by the consumption of 14 tons of that bulky material, while the ice-machine of Dr. Vander Weyde, of this city, which is now being introduced in the United States, is, it is claimed, more economical, and will in its effect excel Liebe's when perfected and worked with superior boilers and engines.

In regard to the cost of the ice thus produced, which is the chief consideration, we may say, it consists of the first outlay, the fuel and the labor. Considering the outlay, an ice-machine with a steam-engine of 40-horse power and boiler, costs, say $5,000, interest of capital, wear and tear of machine, at 15 per cent, $15 per week; labor $18, coal $7, water nothing; total, $40 for 20 tons of ice, or $2 per ton, slightly less or more, according to economy and price of coal and labor.

It is very fortunate that ice-making or conversion of power into cold, is not subject to from 86 to 95 per cent of loss, which is the case, in the conversion of heat into power, in the steam-engine. If this was the case, the tenth or twentieth part only, of ice could be made, with the same amount of machinery, fuel and labor, as now, and the price would be at least $20 to $40 per ton, in place of $2. It is clear that in this case artificial ice could seldom compete with natural ice, which for that price could even be conveyed to the tropics. However inland in tropical climes, it commands often $100 and more per ton, if it is to be had at all, and in such exceptional circumstances, even very expensive methods of cooling may be taken advantage of.

FAGGOTED AXLES.—The Albany Iron Works are making hammered iron railroad axles of a very superior quality. We shall in due time give the particulars of some tests of these axles, under the blows of a drop.

POPPER'S ANTI-INCRUSTATOR FOR STEAM-BOILERS.

By Dr. EMIL TEIRICH.

Translated from "Polytechnic Journal."

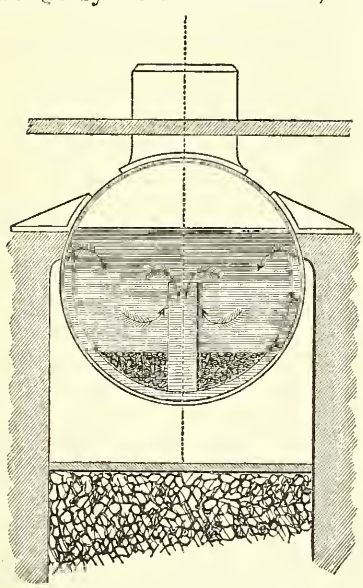
The incrustation of steam-boilers prevents, to a great extent, the transmission of the heat, and causes an early destruction of the boilers. Its removal from time to time is very expensive and inconvenient. The nature and quantity of this incrustation depends on the chemical composition of the feed-water.

When the water is first heated up to the boiling point, the bicarbonates which are dissolved in the water are decomposed, lose one half of their carbonic acid, are precipitated as insoluble carbonates, and produce the first deposit in the boiler. During the subsequent continuous evaporation of the water, the other compounds dissolved in it are concentrated and finally precipitated, when the limit of their solubility is reached. Another kind of deposit is thus produced, different from the first in its chemical composition. The great variety of chemical compounds dissolved in different feed-waters, is a proof that no general chemical means can exist, fit to prevent all incrustation from any water, and that every chemical remedy proclaimed as universal, is to be considered as an imposition. A certain substance cannot even prevent the formation of a certain kind of incrustation unless it is added before the water is brought into the boiler, thus precipitating and gathering the solid compounds outside of the boiler. A chemical analysis of the feed-water can alone give a correct idea of the value of one or other of these chemical remedies for special circumstances. Another method of relieving the feed-water of the greater part of dissolved matter, consists in pre-heating the water in a specially adapted vessel or apparatus, where it then deposits its carbonates. An excessive concentration of the other matters can be prevented by allowing a certain quantity of the contents of the boiler to run out every day, and by replacing it by fresh water.

A third kind of remedy against incrustation does not attempt to prevent the formation of deposits, but alters the nature of these deposits so that they do not adhere, by introducing such matters or arrangements that the deposits may be gathered upon them, and with which they can be quickly and easily removed. We reckon amongst these remedies: painting or covering of the interior of the boiler; mechanical admixtures to the water, which are said to rub and clean the interior boiler surface; the many existing mysterious substances, one of which, viz: Baker's anti-incrustator, has succeeded in acquiring a wide-spread but totally undeserved reputation.

An apparatus invented by Schmitz, and based on a new principle, was favorably received at the last Paris exhibition. By inserting curved wrought-iron plates into the boiler, Schmitz intended to create a regular circulation of the water, thereby to increase the evaporating power of the boiler, and to carry all precipitated matter to the upper surface of the inserted plates. This object is attained in a much more complete manner by Popper's anti-incrustator, and it has been shown most conspicuously by a trial made with it in November, 1868, in the machine shop of G. Sigl, in Vienna, (Austria.)

Popper's apparatus, a section of which is represented by the annexed sketch, consists



of long strips of sheet-iron about 12 in. wide, which are introduced through the manhole into the boiler, and there united so as to form a half-cylinder, placed parallel to the lower half of the boiler. Little projections attached to the outside of this half-cylinder prevent the latter from coming in direct contact with the boiler, but keep it at a certain distance above the interior boiler surface. This distance must be pretty short to make the apparatus very effective. In Sigl's boiler of $4\frac{1}{2}$ ft. diameter as used for the trial, this distance was $2\frac{1}{2}$ in. below the cylinder, and only $1\frac{1}{4}$ in. at the sides. So far, the arrangement is not very different from that of Schmitz. But Popper made a very important addition by inserting a row of vertical pipes of sheet-iron, five inches in diameter, and placed about 24 in. apart. These pipes are supported by the cylinder which has corresponding openings so as to effect a central communication between the water above and below the cylinder. The whole apparatus is set in loose, and kept in place by the weight of a thick layer of pebbles of egg size covering the lower part of the half cylinder. These pebbles, besides, perform the function of taking up all the deposits from the water.

The manner in which this apparatus acts, is indicated by the arrows in our engraving. The steam generated at the heating-surface, rises rapidly in the space between the boiler and the cylinder, creating a strong current, the most important factor of an economical steam-generator. But it does more. The vehemence of the evaporation and the rapidity of the current, prevent all precipitated matters from settling on the boiler plates and throw these matters, together with the water, several inches above the upper rim of the half-cylinder. As this rim is at a level with the lowest water-line, this arrangement is also a protection against the dangergerous consequences of sinking the water below that line. It could be seen distinctly in Sigl's trial-boiler that the water was thrown five or six inches above the normal water-level. It is even to be expected from this system that a continual washing and wetting of the interior boiler walls will take place so long as any notable quantity of water is left in the boiler.

The vertical pipes carry the water back to the heating-surface.

A certain part of the water is always quiet in the interstices between the big stones, where it deposits all the precipitates.

The apparatus is simple and cheap. The boiler in which Popper's apparatus was tried in Sigl's machine works in Vienna, presented a surprising appearance after an uninterrupted working period of three weeks. The interior of the boiler was so perfectly clean, that small impressions which had been made by the hammer during a previous cleaning operation, were yet to be seen distinctly. Also the outside of the half-cylinder was free from incrustation, and showed a metallic surface. The stones were covered with a thick crust of deposits, and so also was a part of the upper surface of the half-cylinder and of the vertical pipes.

To clean the boiler, nothing has to be done but to replace the stones by fresh ones. To do this easier and quicker, the stones will in future be laid into appropriate metallic troughs, in which they remain when in the boiler.

The work of the boiler was regular and undisturbed during the whole trial. The first heating-up was done quicker, the generation of steam was more rapid than usual. According to exact and careful observations, the priming was not more considerable than before. The consumption of coal was very low. As, however, no exact notes were taken about this, the economy of fuel effected by the apparatus could not be calculated for this trial.

Experiments on the applicability of Popper's system on Cornish ship and locomotive-boilers are in preparation, and will doubtless prove as successful as the above.

S.

HISTORY OF WATT'S STEAM ENGINE.

From Sir Wm. G. Armstrong's Inaugural Address before the Institution of Mechanical Engineers, at Newcastle.

This year is the centenary of the steam engine of Watt; and I am glad that it has fallen to the lot of Newcastle to receive, on so auspicious an occasion, a society which must regard Watt, more than any other man, as the father of their calling. First, then, I shall discharge my duty as your president, by paying a tribute of respect to the memory of the illustrious man who, in the corresponding year of the last century, completed and set to work the greatest of mechanical inventions.

In 1765, the authorities of Glasgow College, little thinking of the momentous step they were taking, intrusted a model of a Newcomen engine to James Watt, a maker of mathematical instruments, for repair. The sagacity of Watt enabled him, by an inspection of the model, to detect a radical defect in the principle of the engine. He saw that the condensation effected within the cylinder reduced its temperature, and rendered restoration of the wasted heat necessary at every stroke. He perceived that the steam ought to act in a vessel always hot, and be condensed in a vessel always cold. He thus conceived the idea of separate condensation. With a quiet tenacity of purpose he set to work, under great disadvantages, to realize his idea of a more economical steam engine. His design was soon matured, but the difficulty of execution long remained a barrier to practical success. In the Newcomen engine, the weight of the atmosphere, acting against a vacuum, was the moving power, and leakage of air past the piston was prevented by water resting on the upper side. An unbored cylinder, made in separate parts, sufficed for this arrangement; but in Watt's design steam instead of air acted on the piston. A water packing was inapplicable, and leakage could only be prevented by the more accurate fit of the piston in the cylinder. A moderately steam-tight cylinder and piston were, however, more than the workshops of the day could produce, and we read of his vain attempts to correct, by pasteboard and cork, inaccuracies of workmanship, such as in our time has no existence.

With ailing health, narrow pecuniary means, and a temperament inclining to despondency, he was, in many respects, unfitted for a struggle with difficulty; but he was a man whose mind was taken captive by an idea, and he could not help persevering. His attractive character and fine intellect had attached to him many valuable friends, superior in station to himself, and his letters to some of those friends, written during his struggles, exhibit at once his severe discouragement and his irresistible impulse to proceed.

In 1768, he had succeeded in producing a condenser with its necessary appendage of an air-pump; but it was not until the following year, 1769—exactly a century ago—that his first complete steam-engine was finished and put in motion. The first trial was made by Watt in a secluded glen, behind the house of his friend, Dr. Roebuck, near Linlithgow. The engine was not a mere working model, but a machine of considerable power. It had a cylinder of 18 in. in diameter, and a stroke of 5 ft.; but the cylinder and piston, which were described as the best the Carron Ironworks could produce, were still so inaccurately made as to defeat, in a great measure, the anticipated success. The engine, however, afforded a practical demonstration of the value of the invention sufficient to lead eventually to the happy alliance of the capital of Boulton with the genius of Watt. In 1773, the engine was removed to Mr. Boulton's works at Soho, and was fitted with a new cast-iron cylinder, the casting and boring of which were deemed no small achievement in those primitive days of mechanical engineering.

This first engine of Watt was, like that of Newcomen, only applicable to pumping, but Watt quickly saw by what modifications it could be rendered available for rotative motion. By a succession of brilliant inventions, comprising, amongst others, his parallel motion and his ball governor, he advanced to the final conception of the double-acting rotative engine, which became applicable to every purpose requiring motive power, and continues to this day, in nearly its original form, to be the chief moving agent employed by man.

To do full justice to the genius of Watt, we must consider the disadvantages under which he labored. In the present day, every contrivance is practicable in a constructive point of view, and the vast variety of devices used in modern mechanism, and applicable to new mechanical combinations, are made known to inventors in minute detail by the press. But Watt had no such facilities. He had to draw from his own mind what we can now choose from pre-accomplished invention, and his choice of means was restricted to the narrow limits of what was practicable in the rude workshops of the period. If we give due weight to these considerations, we shall be able to appreciate the remarkable originality of his mind, and the sagacity displayed in his invention. Watt lived to see his steam-engine bear fruit in marvelous utility to the human race; but he could have had no idea of the results it was destined to realize before the first century of its existence. It is impossible to contemplate these results without feelings of enthusiasm. To appreciate how much we owe to the steam-engine, we need only consider for a moment what our positions would be if we were deprived of its agency. The factories which clothe all the nations of the earth would be almost extinguished. The deep mines which supply nearly all our mineral wealth would be abandoned. The manufacture of iron would shrink into comparative insignificance. Horses and sailing ships would again become our only means of transit. All great engineering works would cease, and mankind would relapse into that condition of slow and torpid progress which preceded the subjugation of steam by Watt.

PERMANENT WAY.

Compiled and adapted from "Polyt. Centralblatt."

A great number of engineers are of the opinion that to obtain a solid and permanent railway, causing the least possible maintaining expenses, the wooden cross-ties should be removed, and replaced by more durable materials. The plans which have been designed for this purpose, are principally the following:

1. To lay the rails on stone blocks.
2. To lay the rails on piers of cast iron.
3. To replace the wooden cross-ties by iron ones.
4. To lay stiff and strong, or broad footed rails, directly on the ballast.
5. To lay the rails on longitudinal wrought iron sleepers, in the ballast.

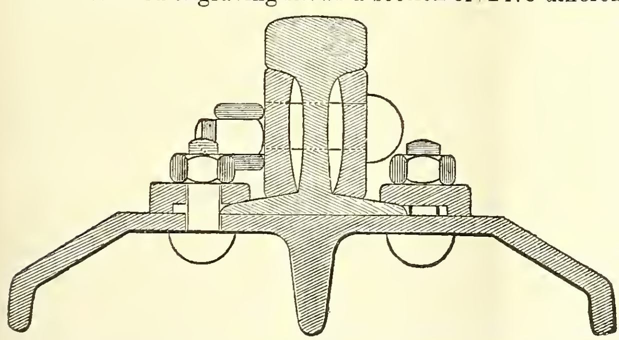
The first method has been introduced on some lines in Bavaria and Wurtemberg, and works satisfactorily when well and solidly constructed. The second method is in use on a larger scale in Egypt, Algeria, England and the East Indies, and a trial is just being made with it on the small route between Leipzig and Magdeburg. Both these systems of construction are not to be recommended for use on a new embankment, because when the latter settles they yield too easily, and cause disturbances in the track.

Iron cross-ties are used on some lines in France, Belgium and Spain. Vautherin's system, especially, has been introduced on the French Northern Railroad, and recently on the Saarbruck Railroad. The rails are fixed to the ties by wedges. This system is more appropriate to new railroads than the two former, as the width of the track cannot be altered by the settling of the embankment. But the construction requires much iron, and is, therefore, very expensive. It is, besides, to be feared that the wedges used may not stand long, and that they may widen the wedge holes, and become loose after some time.

The fourth method of constructing permanent way, consists in laying very rigid and strong rails directly on sand or gravel, or crushed stone. This method has been tried with satisfactory results on the Cologne Minden Railroad, where rails 8 in. high, made after the design of Mr. Hartwich, were used for the purpose. These rails were joined by fish-plates 2 ft. in length, with eight screws of 1 in. diameter. The plates are strong and well designed; their moment of inertia being equal to that of the rails. The cost of the iron on this road amounted to 2.65 Prussian thalers per foot ($1.85 gold). If the rail is laid directly on gravel, its foot has to be very broad to get a sufficiently large bearing, or the rail has to be very high to reach as deep below the surface of the gravel as possible. Both ways involve great inconveniences. A very high rail especially, is liable to tip over. Mr. L. Clasen, of Hanover, therefore proposed to lay such rails on a foundation of concrete, imbedded in the gravel. Concrete when well prepared, is a cheap, strong and durable material for railway substructure, and can be easily obtained everywhere. For the purpose of attaching the rail, Mr. Clasen proposes to lay a plate with a small rectangular hole into the concrete about 1 ft. deep, to leave a narrow hole open, extending from the hole in the plate to the surface of the concrete. A bolt, with a hook of peculiar construction at its lower end, would be inserted into the hole and hooked on to the rectangular hole in the plate. The rail would be kept in place by being screwed on to several of these bolts. The latter could be easily removed when broken, and replaced by new ones. The rails have to be joined by strong fish plates, with four screw bolts. To prevent the rails from giving way sidewise, it is proposed to join two opposite rails by wrought iron flats, laid below the foot of the rails, and bent upwards on both sides of the track. This plan has not yet, however, been tried practically.

A very successful trial has been made on the Nassau Railroad (Prussia), with the fifth of the above mentioned methods of railway construction.

The annexed engraving shows a section of



the arrangement. Wrought iron sleepers are laid in gravel or sand, parallel to the track. On these sleepers light rails are fixed by means of small plates, and short screw bolts, and joined by fish-plates. The width of the track is preserved by thin wrought iron cross-ties connecting two opposite rails.

As this system seems to be a decided success, we give in the following a more detailed description of it, as published in "Polyt. Centralblatt," by Mr. M. Hilf, of Wiesbaden.

1. *Rails.*—The rail used has a broad foot and pretty sharp angles below the head, so as to allow of the application of a strong fish-joint. Its weight is little over 51 lbs. per yard, which is about two-thirds only of the weight of the rails used on the same railroad with the ordinary wooden substructure.

The fish-plate has been recognized as the most reliable means for joining the rails. They are, besides, joined below, the ends of two adjacent rails being attached to the same sleeper. This gives a high degree of solidity to the whole system.

The rails have a length of 19 ft. $8\frac{1}{4}$ in., and are slotted in two places near the middle, and clinched by two of the fastening bolts to prevent the rails from creeping. Every rail is attached to the sleepers by eighteen screw bolts, the nuts of which work on small plates, which clasp the foot of the rail, as our engraving shows. The total weight of the eighteen bolts, nuts and plates, necessary to fasten one rail, amounts to 23 lbs. The fastening effected by these means is so solid that its safety is not much endangered if some of the nuts should become loose, which however happens but very rarely. The same straight sleepers are used for laying curved tracks. The bolt holes have then to be drilled into the sleepers so as to correspond to the required curves. Five different templets are sufficient to mark the bolt holes for all the curves of from 900 to 6,000 ft. radius. The sleepers have then of course to be laid in a position parallel to the tangent of the curve. The rail being light, does not want to be bent previous to laying, and a curved rail can be turned round when one side of its head is injured.

2. *Sleepers.*—The sleepers are easily rolled into the shape indicated by our drawing. They are all made of the same length, which is 19 ft. $2\frac{3}{4}$ in. They are about $\frac{1}{2}$ in. thick, and weigh $79\frac{1}{4}$ lbs. per yard. Sleeper and rail together are so strong that when laid on supports 3 ft. apart, they are not strained

beyond the limit of elasticity by a weight of 36,000 lbs. As the load pressing on the whole system when in use, is distributed on a pretty large surface, this strength offers more than sufficient security. The shape of the sleeper is such as to present two concavities below, into which the material that forms the bed can be rammed in solid. This material cannot, therefore, give way sidewise, but it becomes the more solid the greater the load pressing on the rail. In fact, the whole construction acquires the more steadiness the longer it is in use. The sleepers themselves are so strong that they will not have to be renewed for a very great number of years.

3. *Cross-Ties.*—There are three wrought iron cross-ties on every 20 ft. of track ; that is, on the length of one rail. They connect two opposite rails directly, having a screw at each end which passes through a corresponding hole in the web of the rail. Two nuts outside, and one inside of the rail, fasten the latter to the tie. The length of the ties is $5\frac{1}{2}$ ft. Three ties with their nuts and washers, weigh together 53 lbs.

The strength and number of these cross-ties is more than sufficient even in sharp curves. The double nuts on the outside are not absolutely necessary, but are safer, especially with sharp curves.

The cross-ties are easily detached, when rails have to be exchanged. The enlargement of the track in the curves can be exactly regulated by the ties and the nuts.

The total weight of the construction above described, is for the length of one rail as follows :

Two rails 19 ft. $8\frac{1}{4}$ in. long, 51 lbs. per yard	669 lbs.
Two sleepers 19 ft. $2\frac{3}{4}$ in. long, $79\frac{1}{4}$ lbs. per yard	1,016 lbs.
Thirty-six screw bolts, with nuts and small plates	46 lbs.
Three cross-ties, with twelve washers and eighteen nuts	53 lbs.
Two pairs of fish-plates, with eight screw bolts	44 lbs.
Total weight for one rail-length	1,828 lbs.
or 278 lbs. per yard.	

The total and full cost of the whole iron superstructure, including the laying, was $9\frac{26}{30}$ Prussian thalers per meter, or $6.32 gold, per yard of track. The expenses for maintaining a track of the above construction are very small.

A length of 490 yards of this track was laid in 1867, in the station at Asmannhausen, on the Nassau Railroad. The ordinary kind of rails was used. A part of the rails were fastened to the sleepers by rivets instead of screw bolts. 380 yards of the said track were laid in curves of 500 to 700 yards radius. Eight trains were run over the track daily. None of the rivets or screw bolts had become loose, and no part whatever of the track had been deranged at the end of the year 1868. The gravel on both sides of the rails and sleepers has grown hard on the surface, and the crust thus formed never shows the least cracks, which proves the solidity of the construction. The trains run smoothly over the track without any concussion at the joints of the rails. No bad influence of the weather has been observed, although the drainage of the track is very imperfect. The position of the sleepers has not been disturbed by a temperature as low as 5° F. above zero.

In consequence of the excellent results of this trial, a similar track was laid between Ober-Lahnstein and Ems, on the Nassau Railroad, a distance of about two German miles, containing several curves of 330 yards radius. This line is completed, and proves to be a perfect success. The trains run steadier and with less noise over this track than over the rails laid on wooden cross-ties. The iron sleepers lie perfectly firm. The rails do not alter their position in the least, not even when the cross-ties are removed, and when the trains run over the track at full speed. This shows that two cross-ties per rail would be quite sufficient, especially on straight lines. A part of the above mentioned line was laid down in such a manner that every single rail rested on a single sleeper, the joints being thus suspended. This was done because it was feared that the motion of the cars would not be perfectly smooth with fixed joints. This apprehension was, however, not verified, and as the latter arrangement gives the track a greater solidity, it will be preferred in future constructions upon this system. S.

The Creeping of Rails on a double track, where all the trains run way over them, has got to be a very serious matter with our old fashioned methods of laying. The spikes used with a common chair are utterly inadequate ; with a continuous-lipped chair they answer tolerably. But the Reeves chair makes a better joint than either—better than the fish-joint with low rails—and it entirely prevents creeping.

LIGHTING COAL MINES.—The awful loss of life which has been occasioned, both in this country and abroad, during the past few years by colliery explosions, is at last, we are glad to see, in a fair way to receive the attention it merits; and we trust that the next session of Parliament will not be allowed to pass without some material improvement being made in our legislation on the subject of colliery management. It is quite time, not only that the thoroughly efficient ventilation of coal mines should be rendered compulsory by law, but also that means should be adopted to ensure that the law is carried out. Quite apart from the ventilation, also, means should be taken to ensure the proper lighting of coal mines, and this lighting should be so effected that, even in the event of the ventilation of a portion of a mine becoming temporarily deranged from accidental causes, no harm could result. The safety-lamps now used, though no doubt excellent in their way, give but a very miserable light, and those who have studied the causes of past explosions, well know that these have been in many instances caused by miners opening their lamps to get a little extra illumination. The surfaces of a coal mine, in fact, possess such great light-absorbing power, that none but a very powerful light can be regarded as a really efficient one.

Bearing these facts in mind, Mr. Henry Bessemer, in a letter addressed by him to the "Times" a few days ago, has suggested a method of lighting coal mines which appears to us well worthy of careful attention. As some of our readers may be aware, Mr. Bessemer has been lately engaged in investigating the action of combustion under high pressures, and the results which he has obtained have led him to consider that lamps in which the combustion goes on under pressure exceeding that of the atmosphere, might be advantageously employed for lighting mines. Thus, he states, for instance, that an iron box, having one side fitted with a bull's-eye, or formed of thick plate glass, may be fitted with an ordinary gas-burner, supplied with gas from a gasholder above ground, and that the air to support combustion may be supplied to this box by a suitable pipe at a pressure of, say, 1 lb. per sq. in. above the pressure of the air in the mine, a small hole being left at the top of the lamp for the escape of the products of combustion. Under such circumstances not only would the light produced by the combustion of the gas be intensified, but the pressure within the lamp being in excess of the surrounding atmosphere, the latter would be prevented from entering, and consequently, even if an explosive mixture existed in the mine, it would be perfectly safe from ignition.

Such is Mr. Bessemer's plan, and an admirably simple plan it is. By the aid of a series of brilliant lights, such as he proposes, the galleries of mines may, as he says, "be lighted like a workshop," and there is really, as far as we can see, no good reason why this should not be done. The supply of air and gas, under suitable pressure, presents no practical difficulty, and by the aid of suitable reflectors, one powerful lamp, such as we have described, would be enabled to give a good light for some considerable distance around it. By the aid of easily contrived arrangements, also, some of the lamps might be made to a certain extent portable if required, but in such a case care would of course have to be taken to protect the glasses from accidental fracture. Mr. Bessemer states that he is "convinced that the thorough lighting of a coal-pit, and its ventilation so as to insure health and safety to the miners, are purely a question of £ s. d.," and in this opinion we perfectly agree with him. We do not consider, however, that in matters of this kind any question of expense should be allowed to interfere with the adoption of thoroughly efficient arrangements, and we think that it should be placed beyond the power of any colliery proprietors, actuated by parsimonious motives, to risk the lives of the men employed by them. As in the case of boiler explosions, the experience of past years has taught us that a knowledge of the risks to which they are exposing not only themselves, but others, is not of itself sufficient to make all men adopt means to avoid these risks; and it is, we think, time that both boiler owners and colliery proprietors should be made to feel their responsibilities more strongly. How this can best be done is a matter which we shall not discuss here, as it is to a certain extent foreign to the object of the present article, which was specially to bring before our readers the system of lighting we have already described, a system, we may add, which has not been patented. The fact of a good invention being public property, has but in too many instances proved to be a bar to its adoption, as it has been nobody's interest to show that it was the "right thing in the right place;" we hope, however, that Mr. Bessemer's plan may prove an exception to this rule, and that it may shortly be tested on such a scale as to demonstrate its practical merits.—*Engineering*.

STEAM ON CANALS.

Abstract of a paper read before the Institution of Mechanical Engineers at Newcastle, by Mr. Max Eyth, of Leeds.

In the application of steam power to river and canal navigation, the writer remarked, the greatest obstacle to be encountered had been the loss of power that was inseparable from the ordinary methods of propulsion by paddle-wheels or screw propellers. As the resisting water formed the fulcrum upon which the bearing was taken for propelling the vessel, the result was that a great quantity of water was put in motion, and a considerable amount of power exercised without any useful effect being produced. Thus even under the most favorable circumstances, when working on a broad sheet of deep water, the ordinary propellers lost from 40 to 50 per cent of the power applied to them; and, under the peculiar circumstances met with on rivers and canals, their useful effect was frequently reduced to less than 25 per cent of the power applied. On canals, the increased difficulty to be encountered arose from the presence of locks, the small section of water through which the boats had to be driven, and the swell produced by the increased speed of the boats, for which the small section of water was not originally calculated. Moreover, as the only admissible means of propulsion was by screws or paddle-wheels placed at the stern, the water put in motion by them was withdrawn from the stern of the tug, and thrown against the bows of the boats in tow; the water-level in the canal was thereby disturbed, and the hollow created at the stern of the tug had to be filled up by the water in front of the tug running backwards through the narrow passage left between the tug and the sides of the canal. The consequence of this was that engines of considerable power had to be used for towing a given freight; and hence, owing to the small size of the locks through which they had to pass, it was of the utmost importance that the engines employed should occupy as little space as possible in the holds of the vessels, in order that the cost of steam propulsion might not be further increased by a source of diminution in the amount of freight that could be carried. As it was admitted that a dead pull from a fixed point was undoubtedly the most effective mode of gaining power, it had now been determined to adopt a system on canals and rivers of towing by means of a fixed wire rope and clip drum. The rope was laid in the bed of the river or canal from end to end, being anchored only at its two extremities, and an engine on the deck of the boat was then attached to the rope, and wound itself along to its destination. The idea was not altogether new, as attempts had been made on the Rhine by the French Marshal de Saxe, as early as the year 1732, to transport war material through different rivers of the country by means of a horse windlass on the boats, which wound up a rope made fast on the bank of the river at the extreme end. In 1820, a regular service on the same principle was established on the Rhone, by Tourasse, and it successfully overcame the difficult portions of the river between Givers and Lyons. After noticing the drawbacks of the plan, however, and the many obstacles in the way of a free use of chains or winding drums, the paper added that the present system—consisting of a clip drum working along a submerged wire rope—had been invented and matured by Baron Oscar de Mesnil, a Belgian gentleman, and the author himself; the first experiment having been made at Leeds, in 1866, for Joseph Fowler & Co., and since repeated more extensively on several American canals and also in Belgium. The first application of the submerged wire was made on the river Meuse, where a line 42 miles in length—from Namur to Liège—had been in successful operation since 1868, and was now being extended 90 miles through the Canal de la Campine to Antwerp. Having described the Canal de la Charleroi, in Belgium, the writer added that one of the boats on it was 42 ft. long, by 8 ft. broad, and drew 3 ft. water; while the wire rope, $\frac{5}{8}$ in. in diameter, wound round a 5 ft. clip drum. In addition to these there was a winding drum used for the purpose of obtaining a sufficient amount of slack in the rope for enabling the tug, when off the rope, to hitch on again at any place without delay. The speed of the engines here, 10-horse, was 80 revolutions per minute with 90 lbs. pressure of steam, and the speed varied from one to three miles; but on the river Meuse they had engines of 14 horse-power, working up stream at from three to six miles an hour, although on the downward journeys this could be increased to ten miles by running the engine at 120 to 130 revolutions. In some places, also, they had smaller boats fitted with portable engines—engines that could easily be transferred from one boat to another; and while these were, by a very ingenious contrivance, enabled to pass through the narrowest parts of a canal or the lowest bridges, they could easily travel at $2\frac{1}{2}$ miles an hour with two 200-ton barges fastened behind them. The ropes were in all cases laid along the side of the deck, and never being very long exposed to the air they were not liable to injury by oxidation, neither were they subject to fracture or obstruction on the bed of the river. The rope used on the river Meuse was only 1 in. in diameter, of iron wire, the greater part being galvanized, and having a breaking strain of 14 tons. The weight was $4\frac{3}{4}$ lbs. per yard, and cost, including the laying down, £93. The maximum work done by one tug of 14 horse-power, was towing 18 boats containing a total cargo of 1,000 tons; while, by another, 1,500 tons of freight was towed by 10 boats. Both trips were made up stream, and at from $2\frac{1}{2}$ to 3 miles an hour, including stoppages. The average work of the tugs was to tow 700 to 900 tons of cargo, in 8 or 12 boats of different sizes —the steering in all cases being good— while the average amount of coal consumed by the 14-horse tug amounted to three-quarters of a hundredweight per mile, and the working expenses to £22 per month. The cost of towing on the canals, where the system was now in operation, amounted to not more than .05d. (or one-twentieth of a penny) per ton per mile, including the working expenses, the management, the interest, and the redemption of capital. This result was not only another illustration of the great advantage which inland navigation possessed over any other mode of carrying heavy traffic where speed was not required, but it also proved the important commercial value of this particular mode of towing, as compared with any of the other methods hitherto in general use. The average cost of towage by animal power on four English canals, amounted to .35d. per ton per mile, and on seven French canals was .27d. With paddle tugs on the Thames the cost was .48d., and on six rivers in France it was as high as .80d. per mile. The employment of screw tugs on three English canals resulted in an average cost of .27d.; whilst towing by boats carrying their own machinery cost, on seven English canals, .20d. per mile. In conclusion, the author remarked that while railways had undergone so wonderful a development during the past thirty years, the quieter, but often more important, mode of transporting heavy goods by inland navigation had remained comparatively neglected. It was true that the natural features of England were not very favorable for inland navigation, although there was in the United Kingdom a total length of 2,000 miles of navigable water courses; but on the Continent, in the colonies, and especially in India, there was a vast amount of traffic for which no better highways could be found than those already traced by nature in the rivers and streams penetrating the interior of the country. The system of wire rope towing that had now been described, placed inland navigation in a similar relative position to that in which the road traffic was placed by the introduction of the railway and the locomotive. By means of the clip drum, the tug obtained a hold upon the flexible rope laid on the water course precisely in the same manner as the driving-wheel of the locomotive took hold of the rigid rail upon which it ran; and the great advantage of steam-power might, therefore, be similarly brought to bear on the movements of vessels in water—leaving to railways all their superiority in regard to speed, but restoring to rivers and canals their advantages in reduction of traction.

MECHANICAL FIRING OF STEAM BOILERS.

By Mr. John Daglish.

Abstract of a paper read before the Institution of Mechanical Engineers at Newcastle.

The first part of this paper contains the results of a series of experiments that were arranged and carried out by the writer at Rainton Colliery, chiefly for the practical determination of the question of the utility and economy of side water boxes in connexion with Juckes' furnaces, and incidentally to ascertain the advantage derived from covering boilers, and the best materials for that purpose. A second series of experiments were then given that were conducted at Seaham Colliery, for the purpose of practically ascertaining with certainty the advantages obtained by the use of mechanical apparatus as compared with firing by hand, and the comparative advantage of various systems of mechanical apparatus. Incidentally, attention was drawn to other points, and experiments were made to ascertain the best rate of motion for the bars, thickness of fire, and distance of boiler from firegrate. A third series of experiments were then given that were conducted at Silksworth Colliery, for the purpose of determining the relative advantage of the Cornish boiler for colliery purposes, as compared with the plain cylindrical boiler, prior to erecting a large number for the extensive new coal winning which is now proceeding at Silksworth. Incidentally, the experiments were carried out with different qualities of coal, for the purpose of ascertaining their comparative economic effects. The first series of experiments were made at the pumping engine at Rainton Colliery, which is well adapted for experiments of this kind, as the engine is going continually at an uniform speed. The boilers are in one range, are all of the same size and description, and the temperature of the water was taken alike throughout. They are fitted with Juckes' mechanical firegrate, consisting of an endless chain of short longitudinal bars, traversing forwards with a slow, continuous motion, and thus conveying the fuel from the hopper by a self-acting operation. Nos. 1 and 2 were covered with one description of boiler-covering composition, and were fired by Juckes' mechanical furnaces, 4 ft. broad; while two wrought-iron pipes, 2 in. in diameter, were placed on the inner end, $1\frac{1}{2}$ in. above the bars. These pipes were necessarily exposed to the action of the furnace heat, and, in order to prevent them from being burnt, were constantly kept filled with water. Nos. 3, 4 and 5 boilers were also fired by Juckes' furnaces, to which were added Coulson's water-boxes. These are the full length of the furnaces, 7 in. square, made of half-inch wrought iron; on the inner end they are connected with the boiler by pipes, and have at the outer end a sludge pipe, to remove any scale from the boiler. Nos. 3 and 5 boilers are covered with different kinds of boiler-covering composition, whilst No. 4 is not covered at all. The height of the bottom of the boilers above the fire bars was 2 ft. in three of the boilers, and 1 ft. 6 in. in the others. The quality of coal used was peas, or screened small steam coals; the same quality being used in all the experiments, and the exact quantity of coal used was carefully noted. The time taken in consuming the coals was also noted, together with the number of gallons passed through the special feed pipe; all connexion with the other boilers being shut off. The strokes of the engine were also taken during each experiment by means of engine counters. The result of these experiments may be generally stated to be:

	Pounds of water evaporated per lb. of fuel.
1. With boiler covering, without water-boxes, and with boilers 2 ft. above firegrate	4.83
2. Without boiler covering, with water-boxes and boiler, at 1 ft. 6 in. above fire-grate	4.66
3. With boiler covering, with water-boxes, 1 ft. 6 in. above fire-grate,	5.02
4. With boiler covering, with water-boxes, 2 ft. above fire-grate	5.38

The advantages of water-boxes in increasing the evaporative power of a boiler, as well as in the increased economy of fuel, are therefore very considerable, but those advantages are to a great extent neutralized by the difficuties and increased expense in upholding those boxes. There might be circumstances, however, when their use would be attended by ultimate economy. The advantage of having the boilers at a distance of 2 ft. above the firegate, as compared with 1 ft. 6 in., is also shown by these experiments. With 1 ft. 6 in. distance the effect was 5.02, as compared with 5.38 with a distance of 2 ft., showing an advantage in the latter of more than 6 per cent. It is also found in practice that the boiler is much less injured by the action of the heat at the greater distance. The second series of experiments was made with the range of boilers of the Seaham winding engine, and they are under cover of a boiler house. The boilers are all of the same dimensions, being ordinary egg-ended cylindrical boilers, with a straight flash flue going into the main flue. No. 1 boiler was fired by hand; the heated air, after passing along below the boiler, returns by a side passage, and travels all around the boilers before entering into the chimney. After the wheel flue experiments were made, the flue of this kind was made into a straight flash flue. No. 2 boiler was first fired by hand, with a straight flash flue running direct into the main flue, and was afterwards fitted up with Stanley's self-feeding mechanical furnace. No. 3 boiler was fired with Vicar's self-feeding furnace. Nos. 4 and 5 boilers were fired with Juckes' furnace, of the same description as those already experimented on at the Rainton Colliery pumping engine. From the experiments shown in the accompanying table, the following deductions may be made: First, with hand firing, the quantity of water evaporated per pound of coal, with a flash flue, is 6.66 lbs. as compared with 5.22 lbs. with a wheel flue; and the total quantity of water evaporated is 441 gallons per hour, as compared with 433 gallons per hour, showing the marked advantage of the flash flue over the wheel flue, not only in the economic effect of fuel, but also of boiler space. It is probable, however, that this amount of economic effect (6.66) is considerably higher than that obtained under ordinary circumstances, as the fires were more regularly attended to than is usual with hand firing. Secondly, Juckes' furnaces. This apparatus, invented for firing steam boilers, has been in operation some time in this district, and has lately been adopted very largely at many collieries in the north of England. The advantages of this furnace are, perfect combustion of smoke, and great regularity in raising steam; the saving, in common with other mechanical appliances, in the wear and tear of boilers and in manual labor in stoking, the latter amounting probably to £200 per year per boiler. In comparison with hand firing, it does not seem to possess any great advantage in economy of fuel, the comparative economic effect being 5.09 as compared with 6.66 for hand firing; but the latter is probably a much higher result than what is usually attained in practice. Like all other mechanical appliances, it requires a certain amount of care and attention in its use; but on the whole it may be said to be successful and economic in application. It is not well adapted for using Duff coal, although this is done in some instances when the Duff is washed. Thirdly, Vicars' furnaces. Of all the mechanical apparatuses for firing steam boilers, none seem to be so successful as Vicars', as arranged at Seaham Colliery, though this apparatus, erected elsewhere, seems not to have worked satisfactorily, which was probably owing to the improvements recently made in the apparatus. These now consist of three distinct appliances. The traversing bars, intended to give progressive motion to the incandescent fuel, by a slow alternate and intermittent longitudinal motion; second, the pump feeders, which alternately press a regular supply of coal from the hopper to the bars; third, the water troughs, in which the fire bars are immersed, and which are absolutely essential, as no ordinary fire bars can withstand the intense heat of the fire. This furnace was in constant operation at Seaham Collieries for nine months without requiring any repairs, and in all respects it has been most successful and economic. When using the same class of coal (peas) as in the hand-firing experiments, the economic effect was 7.14, as compared with 6.66; but the maximum results of this furnace have probably not yet been obtained, nor the best conditions as to thickness of fire ascertained, the high amount of 8.78 lbs. of water evaporated per pound of coal being in one instance obtained. This furnace is very efficient in its action in avoiding the formation of smoke. The great advantage, however, attending the use of the furnace is its applicability to the use of Duff coal, or dust coal, with high economic effect. It will be observed that with dust coal the economic effect actually reached is 6.84 lbs. of water per pound of coal. Taking the consumption of fuel in one of these experimental boilers at six tons per day of 24 hours, and taking the comparative price of Peas and Duff coal at 3s. and 1s. per ton at the pit, the commercial economy effected by the use of these furnaces over any other mechanical apparatus not adapted to use Duff coal will be from £200 per year per boiler. The evaporative power of the apparatus does not appear by these experiments to be equal to that of Juckes' or hand firing, although this may arise, as before stated, from the fact of its maximum power not being yet perfectly developed. A somewhat interesting circumstance may be observed in these experiments. The fire-bars used in this special fire are 5 ft. 4 in. in length, whilst those in Juckes' apparatus are 6 ft. 6 in. in length; but although the heat of the fire in Vicars' grate was much more intense than in the Juckes', the pyrometric observations in the flue beyond the boiler invariably showed much lower temperature from the former than from the latter. It would seem, therefore, that the heat developed in the grates of the Vicars' is of considerably higher intensity than that of the Juckes', and as effectual in its action on the exposed surface of the boiler, so that the absolute heat remaining on arriving at the flue is then reduced below that of Juckes'. The experiments with Stanley's apparatus give very irregular results, showing that a lengthened series of experiments, as to speed of dispersers, thickness of fire, etc., would be required before the maximum effect could be regularly attained. In this apparatus, the coal falls through crushing rollers on to two dispersers, or rapidly revolving discs with radiating ribs, which scatter the coal uniformly through the fire by centrifugal action. The advantages of this furnace are that it permits of the use of Duff, or dust coal, and a comparatively large amount of fuel can be consumed per square foot of fire-grate surface. As compared with hand firing, a much lower economic effect is exhibited, being 4.74 against 6.66; but it is more than probable that this arises from the Stanley apparatus not being in all respects arranged to obtain its maximum effects. A few experiments were made with this furnace after the addition of Whittaker's traversing bars, but not sufficient to yield any reliable data. The third series of experiments with single tubular boilers were made with two boilers erected at Silksworth Colliery, for temporary purposes, which were fortunately of exactly the same size, and were constructed with a single tube. They had been previously in use at the Londonderry blast furnaces blowing engine, and were then set over the fire-grate, the draught returning through the tube and thence round each side of the boiler. At Silksworth one of these boilers is set in a similar way, the other having a fire-grate fitted up in the tube and used as a Cornish boiler. This series of experiments was intended also to show the useful effects of external heating surface, and by an arrangement of dampers the smoke could be either taken at once up the chimney, or made to pass all around the outside of the boilers by the external wheel flue. The following are the chief deductions to be drawn from these experiments: First, the advantage in No. 1 boiler, of using the wheel flue, overtaking the smoke direct through the tube to the chimney, is as 5.51 to 4.87; secondly, there is a slight disadvantage in No. 2 boiler using the return tube through the boiler and the side flues, instead of taking the flame direct from under the boiler to the chimney, being as 4.72 to 4.94. The general results of these experiments tend to show the advantage of flush flues, having the usual large heating surface. The most important point, however, to be deduced from the experiments was the small evaporative power of the boilers when fired through a single tube, as compared with the result of firing underneath the boilers, being only 604 and 690 gallons evaporated by the former as compared with 1344 and 1243 by the latter method, the economy of fuel being about the same in each case. The chimney, however, used for these boilers was only temporary, and not capable of producing a draught sufficient for the wheel flues. This fact renders it impossible to make any comparison between these experiments and those made at Seaham Colliery. It must be borne in mind that these boilers are by no means fair specimens of the Cornish boilers; and arrangements are being made to carry out a series of experiments to ascertain the evaporative power and economy of the Cornish boiler as compared with cylindrical boilers. These experiments will be made with boilers recently erected at Hetton Colliery, of improved construction. In conclusion, the writer expressed his thanks to Messrs. P. B. Hood, Wm. Armstrong, jr., and Emerson Bainbridge, for their careful attention in carrying out and tabulating the experiments.

ACCUMULATED HYDRAULIC POWER.

From "The Engineer."

We divided this subject into five heads in in our first article,* namely: (1) Cost of generating the power; (2) Loss by friction; (3) The cost of the machinery; (4) Convenience of application; and (5) Cost of maintenance. These heads we only treated generally and collectively in that article, as our object was to take a sort of "bird's-eye view" of the question; to be afterwards amplified in dealing with each point in detail. In dealing practically with complex problems it is impossible to adopt any system of division or classification which can be adhered to throughout. It is necessary at certain points to admit of a little overlapping of the divisions. We shall endeavor to keep the various divisions as distinct as may be, but we shall not hesitate to sacrifice mere classification to the more important considerations of clearness and practical convenience. Having thus far explained the "base of operations," we shall proceed to the discussion in detail of the "cost of generating the power."

Water pressure, such as we are discussing, can only be obtained by pumping into an accumulator, as the high pressure required exceeds that of any natural "head." As, for instance, in the case of the extensive sets of hydraulic cranes, hoists, &c., which have been introduced by Sir W. G. Arm-

* See Van N.'s Magazine, September, page 778.

strong & Co., the pressure most commonly adopted is 700 lbs. per square in.—a pressure corresponding to a head of about 1,600 ft. It is needless to observe that such a "head" as this is not obtainable either naturally or artificially in any of those localities where it would be commercially available. Even the lower pressures of 300 lbs., and 500 lbs., per square in., which have been adopted in our chief steel and iron works, would require respectivelyel evations of 700 ft. and 1,150 ft. These pressures, therefore, are only obtainable by the use of a loaded accumulator, and *à fortiori*, those higher pressures of two and three tons per in.—of which we shall treat in the course of our present inquiry—are necessarily so obtained.

We shall first consider those cases where a steam engine is employed to work the pumps, such being the rule, though it will be necessary to discuss some very important exceptions. With the question of the economic production of steam in the boiler we have not to deal, nor is it within our present purpose to discuss any points affecting the engine *per se;* though both these parts of the general apparatus must play a most important part in determining the question of absolute economy. Their selection lies, however, in the province of steam engineering.

It will be necessary, nevertheless, to consider the use of the steam in the engine as far as the same is affected by the construction of the hydraulic apparatus and the mode of conveying power from the engine to the pumps. The simplest way of looking at the work to be done is to consider the accumulation of the power merely in the light of a load raised a given height. The "head" of water which would correspond to the pressure per square in., is the measure of the height to which the load is to be raised, if such load be taken as the weight of the water pumped. If, on the other hand, the load on the accumulator be taken as the load to be raised, the distance through which the ram of the accumulator is raised is the measure of height. In the first case we have a small load raised to a great height; in the latter a larger load lifted through a less height. The first represents the amount of work by a theoretical expression, while the latter gives the actual state of the case. We shall have occasion to refer to each in its place, but we may call attention to the fact that the first is by far the more convenient, as the quantity of water pumped can be at once stated, or, in practice, ascertained by measurement; the total lift of the ram of the accumulator could, on the contrary, only be ascertained by complicated systems of addition and substraction, the actions of the machines keeping the ram in a constant state of upward and downward movement. We have got, then, a load, which is continuous, to be lifted to a given height. This load is, by its very nature, inelastic, and to raise it by an elastic force, as of steam, requires special adaptations to guard against waste of power. Clearly, the worst possible way to raise a load by steam power would be by the direct action of the steam, as, expansion being impossible, the steam must be discharged with the major portion of its energy undeveloped. Yet we have seen this done where an engine of the "direct-acting" class, with the steam piston-rod passed through the ends of the steam cylinder into two small hydraulic cylinders, was used for pumping into an accumulator at a pressure of about two tons per inch. Not only is there here the ruinous waste of steam, but as the speed of the steam piston cannot exceed that of the hydraulic pistons, a very large steam cylinder would be required to work a sufficient quantity of steam.

The speed of hydraulic pump plungers working at high pressures must be slow while a high speed of piston is advisable for steam engines, as reducing the cost and size of the engine and also facilitating expansion. The steam piston should run at from five to ten times the speed that the hydraulic plungers work at. It is therefore necessary that some sort of intermediate gearing should be used between the engines and the pumps; and also that provision should be made in the engine for a sufficient power of momentum to enable expansion to be fully carried out. There is a great advantage in the facility with which expansion can be carried out in engines employed in pumping into accumulators. No self-acting expansion gear worked from the governor is necessary; the load being constant, the cut-off may also be constant. Where engines are specially made for this work, it is advisable to use two cylinders connected to cranks set at right angles on one shaft. On this shaft should be a fly-wheel of a weight suited to the rate of the engine and the degree of its expansion. A second shaft should, by means of short, strong cranks, drive the hydraulic plungers, these cranks being opposite to each other. This second shaft is to be geared to the first by accurately made tooth gearings of the proportions before mentioned. Such a construction as this is simple and in every way effective.*

It is requisite to provide an arrangement to the accumulator, such that when the ram reaches a certain height, the supply of steam to the pumping engine may be cut off; and also that when the ram falls a little below that point, the engine shall be retarded. The valves of the pumps and accumulators must be as straight in the passages as they can be made, and the pipes between them as free from bends—particularly sudden ones—as may be. The propelling of the water through bends and all confined passages is analogous to the drawing of a loaded carriage over stones or other impediments, and seriously increases the load against the engine. It is also a mistake to use pipes of small diameter, since there is a loss of power, not only in increasing the velocity of the current of water, but also in the greater surface presented by such pipes in proportion to their area. In employing long ranges of pipes it is better to put an accumulator at each end. The pumps should in all cases charge the accumulator by pipes distinct from the service pipes, which convey the water to the machines, as otherwise there will be continually opposing currents in the pipes when the machines are in use.

In some situations it may be found advantageous to work the pumps by means of a water-wheel or a turbine. The principles laid down in treating of the use of a steam engine for this purpose are applicable to such cases, except as regards the remarks about securing expansion. With the water-wheel or turbine the motor and the load are alike inelastic. From the shaft of a water-wheel the hydraulic pump plungers would be worked direct, while from a turbine a very great reduction of speed would be required; but in neither case would the addition of any "vehicle of momentum" be requisite.

We have spoken entirely of loaded, to the total exclusion of atmospheric accumulators, for the following reasons: In charging an atmospheric accumulator the diagram would show a curve of compression indicative of the power required for the work of charging. In using the pressure it would be impossible to obtain anything even approaching the reverse curve; therefore a serious waste of power must result. But this is not all. A very considerable amount of heat must be evolved which is totally lost; while there is yet further the weighty practical objection that the pressure continually diminishes as the machine operated moves. The inconvenience and loss thus caused are very serious, as a very great amount of power is used, and there is the least of it where the most is required. These shortcomings are in themselves sufficient to condemn the atmospheric accumulator; added to these is the very great risk of keeping air at so great a pressure. In most cases where atmospheric accumulators have been put up they have since been abandoned. The inducement to use them lay in their small first cost, and the absence of working parts to keep in repair.

There is one advantage appertaining to the atmospheric accumulator, namely, its causing little or no shock to the machines and fittings. With loaded accumulators as usually made, this shock is very injurious, and is only partially met by "relief" valves; in fact, the "relief" valve is usually fitted to ease the shock in stopping the machines by letting back the pressure against the accumulator. The load on the ram ought to be suspended on strong but lively springs, to take up the momentum of the load after a "fall." We have ourselves seen a load of twelve tons dropped 9 ft. with such quickness as to be practically equal to a free fall of that distance. For such a load to be suddenly stopped by an inelastic fluid like water must be eminently injurious to all the fittings and joints. Such injuries might be to a great extent guarded against by the adoption of efficient springs. In the annular "dished spring"—a simple steel washer—invented by Mr. F. A. Paget, C. E., and extensively applied to similar purposes on railways in France, we have just the thing required—a spring which can be placed round the rod by which the load is suspended, thus occupying little room, and capable of any amount of reduplication. The cheapness of these springs—which will do in Bessemer steel—is of importance as regards the question of cost which we are discussing.

Where machines are at long distances from the accumulator, it may be advisable in some cases to put "relief" plungers in small cylinders, with either weights or springs to absorb some part of any sudden shock occurring. In all cases where the

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* Before saying too much about the simplicity of this engine, the author should look into the Worthington duplex pressure pump used in American steel works.—*Ed.*

work is heavy and intermittent, particularly if the power has to be conveyed long distances, its generation and conveyance by hydraulic apparatus will be a source of economy.

The economy of having a constant load against the engine has been already pointed out; and the economy of conveyance through long distances will be perceived from the fact that water pressure conveyed through upwards of two miles of pipes showed no perceptible loss of power. Shafting, on the other hand, if carried to any considerable length, absorbs a great deal of power to overcome its friction, entails a constant expense for lubrication, and is subject to considerable wear and tear. In conveying power by water, the distance makes but little difference in friction, there is no expense for lubrication, nor is there much wear and tear. Beyond this, pipes are cheaper to lay than shafting, can be laid where shafting cannot, and do not require protection from dust.

As against these sources of economy may be set the fact that, when not fully loaded, there is a proportionate loss of power with hydraulic machines, since the power used is always the maximum, whatever the load may be. It is questionable, however, whether the economic working of the prime mover does not more than counterbalance this; and while with shafting, machines must be started and stopped suddenly, with hydraulic pressure any graduation can be obtained. There is also a beautiful steadiness of motion—due to the want of elasticity in the water—which is of great value in most mechanical operations. We shall have a better opportunity of speaking of this latter advantage in dealing with the fourth division of our subject.

In connection with the cost of generating and accumulating the power, we would call attention to the feasibility, in many cases, of aiding the pumps by returning the water under pressure from a descending load. Take the case of a lift, where heavy wagons or cages have to be raised full and sent down empty. It would, in such a case, be possible to effect a considerable economy by leading the exhaust pipe direct to the pumps; as whatever might be the pressure exerted by the descending load, to that extent would the engine be relieved, and a corresponding economy effected. A case of this kind occurred at the Mersey Ironworks. A steam pressure of 45 lbs. was required to charge the accumulator when the water was discharged from the exhaust in the ordinary way. On changing the arrangement, so as to carry the exhaust water in confinement to the pumps, 25 lbs. sufficed. The merit of this arrangement is due to Mr. W. Clay. A somewhat similar arrangement has been for some years in use at Newport in Monmouthshire. In this case a small ram is driven back against the pressure of an accumulator by the descent of a box loaded with coal; such box being then discharged into the colliers' hold, is raised by the power accumulated by its descent, the difference of the weight when empty allowing for the friction of the apparatus. In some instances it is preferable to use a counterbalancing weight. These contrivances are, however, noticed here merely as means of attaining economy in the power. Their further discussion will come under the head of designing hydraulic apparatus.

We have advanced sufficient proof of the comparative economy of accumulated power for many purposes; its absolute cost will of course greatly depend on purely local causes, such as cost of fuel and labor.

FEED WATER.

ITS CHEMICAL AND PHYSICO-CHEMICAL EFFECTS.

F. A. Paget, Esq., C. E.

From "The Locomotive."

The wear and tear of a boiler which occurs in the form of corrosion, properly so-called, may be divided into two principal kinds: (1) internal and (2) external. The progress of both is necessarily intensified by the mere effects of temperature; each, however, has its strongly marked, distinct character—not merely as to position, but also as to origin and results.

A steam boiler is in the position of a vessel into which large volumes of water are continually forced; while the heat applied, driving off all volatilizable matter, leaves behind a concentrated solution with a chemical character dependent on that of unvolatilizable matters in the feed-water. The specific gravity of the substances found in the water naturally causes them to sink towards the bottom, at which part the solution is generally more concentrated, however much it may be stirred up by the ebullition. Mr. J. R. Napier lately stated that a piece of zinc "about 4 ft. long, by 3 in. broad, by $\frac{3}{16}$in. thick, placed in a marine boiler for three weeks" to a depth of 18 in. in the water, showed a corrosion which rapidly decreased "up to the highest part, which, in the steam, appeared to be little affected."* This accounts for the fact that all boilers, even those internally fired, like locomotive boilers, have their plates most affected towards the bottom, and that internal corrosion always shows itself to a greater extent below the water line. The *bouilleur* of the form of boiler known as the French boiler, is also generally more affected than any other part. To resist this sort of slow action, it is clear that the more the bulk of metal the better, and it is for this reason that the bottom plates of most marine boilers are made thicker, while these same plates in locomotive boilers have to be often renewed. Any chemical or physico-chemical action of the kind is of course intensified by temperature, and this is one of the causes why externally fired boilers give way most, a little in front of the furnace. But the plates above the water line also get more or less corroded, and not merely with the usual character of rusting, but in that peculiar form known as pitting, which generally shows itself much more strongly marked below the water-line.

The presence of a concentrated solution of an acid or alkaline character, kept at a high temperature for years in contact with iron plates, would be sufficient to account for much corrosion. But the internal corrosion of steam boilers has many features of such a mysterious character, that no accredited explanation of its attendant phenomena has yet been put forward. In the first place, plates thus attacked show a number of irregular holes like a pock-marked human face, or like the small craters seen on the moon's surface.

The writer has also sometimes observed two or three little irregular excavations like this in a plate otherwise showing a large surface quite intact. Sometimes the plate is most pitted round a projecting bolt; at others, one plate will be perfectly sound, while that riveted to it will be almost eaten away, both having been the same time at work, and under, of course, apparently exactly similar conditions. With locomotive boilers this pitting has been ascribed to galvanic action between the brass tubes and the iron plates. But it is notoriously well known to locomotive superintendents, that boilers with iron tubes are often worse pitted than those which have run the same distance with brass tubes. Besides, all iron boilers, with or without brass, whether used for stationary, locomotive, or marine purposes, are subject to pitting.

An explanation which seems to meet all the circumstances of the case is the following: Mr. Mallet, in a report addressed to the British Association, some years ago, showed that wrought-iron and steel (blister-steel, probably) "consist of two or more different chemical compounds, coherent and interlaced, of which one is electro-negative to the other." In fact, ordinary wrought-iron, being also welded up from differently worked scrap, is far from being an electro-homogeneous body. In a boiler, the hot water, more or less saturated with chemical compounds, is the exciting liquid, and the electro-positive portions of the plates are thus quickly removed to a greater or less depth. This explanation meets most of the known circumstances with respect to pitting; it even, in a great measure, explains how plates above the level of the water, especially in marine boilers, get very rapidly corroded in portions, while another part of perhaps the same plate is scarcely affected. The concentrated water in a marine boiler is known to be generally acid. "Of all the salts contained in sea-water," says Farraday,* "the chloride of magnesium is that which acts most powerfully" on the plates. He shows that a cubic foot of sea-water contains 3.28 oz. of this salt; and, at the same time points to the danger of voltaic action in a boiler through the contact of copper and iron. In a smaller degree the contact of cast with wrought-iron, or between the different makes of wrought-iron in the same plate, or between contiguous plates, acts in the same way. It is not improbable that some hydro-chlorate acid is present in the steam of marine boilers. "Mr. J. C. Forster† has tested some of the condensed steam from the safety-valve casing, and from the cylinder-jacket of the Lancefield, and found both decidedly acid.‡ With an exciting liquid in the condensed steam, it is thus explicable how the plates of marine boilers often get corroded in a most capricious manner; while at the same time, the current of

* Institution of Engineers in Scotland, Session 1864–5.

* Fifth Report of the Committee of the House of Commons concerning the Holyhead Roads, p. 194.

† Institution of Engineers in Scotland, 1864–5. Introductory address, by Mr. J. R. Napier.

‡ When a solution of chloride of magnesium is evaporated nearly to dryness, the salt and the water are decomposed, magnesia and free hydro-chloric acid being formed; or $MgCl + HO = MgO + HCl$.

steam would create a certain amount of friction on the oxide, clearing it away to act on a fresh surface.

The crucial test of this explanation of pitting would be the observation of the absence of the phenomenon from plates of an electro-homogeneous character. This homogeneity could only be expected from fused metal, such as cast steel. Accordingly, while the writer was in Vienna a short time ago, he was assured by Mr. Haswell, the manager of the Staatsbahn Locomotive Works, that some locomotives made of cast steel plates, in 1859, for the Austrian Staatsbahn, had been working ever since without showing signs of pitting, though under similar conditions iron plates had severely suffered in this way. Pitting may thus be fairly defined as a form of corrosion localized to particular spots by voltaic action. It is also probably aggravated through the motion of the plate by mechanical action, and the expansions and contractions through alternations of temperature. All boilers are most pitted near the inlet for the feed-water, and with inside cylinder locomotive boilers there is generally more pitting at the smoke-box end—no doubt caused by the more or less racking action on these plates. A state of corrosion at particular spots would probably be kept up to a greater intensity by the incrustation being mechanically thrown off. With a quicker voltaic action, caused by any unusual intensity of the exciting liquid, the sides of the cavities in the plates would be sharper and less rounded off; as in the case of a boiler fed with mineral water from ironstone workings, which exploded last year at Aberaman, South Wales.

The fact that pitting occurs in marine boilers when distilled water from surface condensers is used, does not effect this explanation. Water distilled in this way, from whatever cause, after repeated boiling, is stated to carry the salinometer even higher than sea water, thus proving that it is not pure.* In the next place there is the absence of incrustation, which to some extent protects the plates of boilers from the chemical action of its contents. In this way the mechanical buckling of the plates—directly and indirectly causing the furrows we have spoken of—by continually clearing particular lines of surface from incrustation and oxide, reduces these particular spots, with respect to corrosion, to the condition of the plates of a boiler fed with water which deposits no incrustations. Corrosion will also act more rapidly at a furrow through mere increase and renewal of surface. To resist that form of internal corrosion specially known under the name of pitting, a maximum of electro-homogeneity is evidently required in all the component parts of the boiler.

While the action of internal corrosion, often very equally corrugating the plates over a large surface, as a rule scarcely, at any rate only gradually, affects their mechanical strength, external corrosion, being localized to particular spots, is of a much more dangerous character. The one is gradual and easily perceptible, while the other is rapid and insidious in its progress. Apart from accidental circumstances affecting the brickwork on which a stationary boiler is erected, or the outside of the bottoms of marine boilers, it is clear that external corrosion can only occur through leakage. When leakage takes place through a crack in the plate caused by mechanical action, or at a hole burnt out by heat, the effects of leakage are only secondary results, due to a primary cause which of itself may cause the stoppage of the steam generator. But a leakage at a joint may in itself gradually cause the destruction of the boiler. Here we see another reason that the character of a boiler, not merely as to ultimate strength, but also as to wear and tear, intimately depends upon the form of its joints. It is often noticeable that very good lap-joints, even when tested under hydraulic pressure up to only 50 per cent above the working load, sweat more or less. The tendency of the internal pressure to form a correct circle bears indirectly on these joints, causing them to open, more or less, and to leak, in spite of the caulking. Mr. Robert Galloway, C. E., who, as an engineer surveyor of long standing of the Board of Trade, has probably made more than three thousand careful inspections of marine boilers, states that he has often noticed a furrow or channel on the outside of the joint, running parallel to the outside overlap for some distance, and evidently caused by leakage. Along the water line, condensed water will act on the joints, while below it the concentrated contents of the boiler will come into chemical action. A leakage in a marine boiler often eats away a plate within a year. In some cases a jet

* Institution of Mechanical Engineers, 1863. Discussion on Mr. James Jack's paper "On the Effects of Surface Condensers on Steam Boilers."

of hot water from a leakage has a frictional action; in fact, even with such an incorrodible and hard substance as glass, an effect like this has been perceived, and a slight leakage continued during several days sometimes produces a noticeable furrow on a glass gauge tube. With sulphurous fuel, a powerful chemical action will come into play on the plates. One volume of water takes up about thirty volumes of sulphurous acid gas; and these sulphurous fumes of the fuel, coming into contact with the water from a leakage, will be more or less absorbed. An acid solution like this must quickly eat away the plate. It is certain that a leakage acts much quicker on a boiler fired with sulphurous fuel than on one fired with wood. M. G. Adolphe Hirn has observed a plate, nearly seven-eighths thick, to be pierced, in the course of time, as with a drill, by means of a little jet which struck it after passing through a current of hot coal smoke.*

* Bulletin de la Société Industrielle de Mullhouse, 1861, p. 558.

CONDENSATION IN STEAM ENGINES.

By M. E. Cousté, Government Director of Manuf. Translated from "Annales du Génie Civil."

(Concluded from page 805.)

It is apparent that, among the causes of the inferiority of the surface condenser, incrustation is one of the most efficient. It will therefore be proper to examine whether there be any method of preventing, or, at least, of diminishing it.

1st. The condensing water, whether derived from wells, from rivers, or from the sea, always contains incrusting salts, such as bicarbonate of lime, in the case of fresh water, and bicarbonate of lime and magnesia in salt water. These salts, losing a portion of their carbonic acid, will deposit neutral carbonates upon *the exterior face* of the condenser, unless they are converted into soluble salts by the addition of sulphuric or hydrochloric acid. But as sea-water, and most fresh water, contains more than .0002 of carbonates, the use of these acids, however cheap they may be, would be very expensive.

2d. As to *the interior surface*, nothing can prevent its incrustation. Indeed, supposing even that the feed water be perfectly distilled, and contain no salt in solution, it will still hold in suspension insoluble matters, resulting from the boiler cements, from the wear of sliding surfaces, and especially from the oxide of iron, which is produced abundantly. The steam, carrying a certain quantity of these substances in a state of minute division, deposits them upon the condensing surface, where they form a crust, which is much aggravated by the lubricants, also introduced by the steam. It would be hopeless attempting to remedy these difficulties by filtering the water after issuing from the condenser, and before injection; this would be merely a palliative, since incrusting matter is constantly forming in the boilers, in the cylinder, and in the steam pipes.

3d. Finally, these substances, supplied by the various members, are by no means the only ones which contribute to the incrustation of the internal face. Practically, it is impossible to make a surface condenser perfectly tight. The extent of surface required necessitates the use of very many small flues (4,000 to 5,000 for an engine of 350 horsepower). In the great number of joints occasioned by these flues, owing to the frequent alternations of temperature, there will always be some leaks, through which the exterior water will be forced by atmospheric pressure. The water in the boiler thus becomes rapidly charged with incrusting matter, which is deposited in crystals of carbonate and sulphate of lime, and, in the case of sea water, of free magnesia.

It may also be remarked that with the cold water entering through imperfect joints, are introduced the gases which it holds in solution, whose presence in the flues of the condenser neutralizes the effect of the vacuum.

4th. The incrustation of the surface condenser is therefore inevitable. But will it be practicable to diminish it by a systematic method of cleaning? In a previous paper on the incrustation of boilers I indicated, in reference to a structure having a close resemblance to the surface condenser, a method of cleaning, which might be applied here. It consists in providing an alternate condenser, thus admitting of the rest of one of them which would allow the application to the exterior of the flues of a weak solution of hydrochloric acid, in order to dissolve the carbonates, and to the interior, of a concentrated boiling solution of carbonate of potash, in order to break down the thick scale and facilitate its removal by means of the ordinary flue scraper.

Having established the general theory of condensation, and deduced the superiority of the injecting over the surface condenser, and having enhanced this superiority by indicating the improvements of which it is susceptible, it remains to demonstrate that it is applicable to marine engines, as well as to other condensing engines, and to describe the method of its application.

The obstacle in the way of condensation by injection in marine engines working at high pressures is not in the principle of condensation, but in the water-supply of the boilers. By the mere elevation of temperature the feed water precipitates its calcareous salts, even without the added effect of progressive concentration, and deposits them in the boiler, partly in the form of scale, which diminishes the transmission of heat, and partly in the form of small crystals, which gather upon the heating surfaces. When the pressure does not exceed 1.5 to 2 atmospheres, or the temperature does not exceed 121°, the point at which sea-water dissolves twice the quantity of sulphate of lime which it contains naturally, blowing out may be resorted to at suitable intervals. This will retard, but will not wholly prevent incrustation. But even this resource is no longer available when the pressure rises to 2.4 atmospheres and the temperature to 127°, since, at that point, the water begins to deposit its sulphate as soon as it enters the boiler.

It is essential, then, to obtain a feed water free, or nearly so, from calcareous salts, and for this purpose the surface condenser was devised as a simple method of obtaining distilled water, which was most reasonably supposed to be eminently suited to boiler supply.

Generally speaking, then, the function of the condenser may be said to consist of two distinct acts: 1st. Transferring the heat of the steam to cold water, thereby condensing the former. 2d. Eliminating from the engine all of this heat, except so much as is returned to it in the feed water. In both forms of the condenser these two acts are performed *simultaneously*, and in the interval of time occupied by two strokes of the piston. But the general performance of the engine requires only that the first act should be accomplished rigidly within the time just mentioned; the other may be effected at leisure with the sole condition, that it be done in such a manner as not to impede the condenser. This state of facts allows the practical application of the *monohydric* principle of condensation, which consists in ejecting into the condenser the same water, continuously and repeatedly, which will be non-incrusting, if previously deprived of its calcareous salts, and in refrigerating it each time it passes the condenser, without intermixture with the cooling water. It is clear that if refrigeration is made a separate operation, entirely independent of the condenser, we shall have all the advantages of injection and a non-incrusting feed water. This principle is not new. It has already been applied to pumping engines in mines where the water is acid and corrosive. I have myself given an application of it in a memoir on incrustation, with the plan of a refrigerator for effecting the repeated cooling of the injected water. I propose to employ it as an accessory of an engine, provided with an injecting condenser, and for a detailed description of it I beg leave to refer to the memoir in the *Annales des Mines* (September and October, 1854). The following is a brief description of the refrigerator:

"The water drawn from the condenser is raised by a pump to a reservoir placed at an elevation of several meters, and underneath this reservoir is located the refrigerator, composed of vertical copper tubes, surrounded by a cylindrical copper shell. The warm water descends from the reservoir through the tubes, which are immersed in the cold water, which is constantly renewed by a current moving from below upwards, i. e., in a direction contrary to that of condenser water."

It is plain that the apparatus employed in the English practice as a surface condenser might be used as a refrigerator, requiring only to be placed in such a manner that the tubes be vertical instead of horizontal, or slightly inclined. The vertical position is essential to a regular and perfect method of refrigeration, since it exposes the descending water to colder surfaces of refrigerating water the lower it descends.

"To avoid the incrustation of the interior surface caused by the lubricants there may be occasionally introduced into the tubes a hot alkaline solution, which will saponify the crust. For cleaning the exterior surfaces of the tubes a process is adopted analogous to the preceding. It consists in introducing into the cold water space a weak solution of hydrochloric acid, which will dissolve the carbonates. By means of a system of suitably arranged valves both operations may be effected promptly, without labor and without deranging the action of the engine."

As to the details of construction, especially the setting of the tubes, their diameter, etc., one could not do better than follow the established rules of English practice for surface condensers.

Although I see no reason to doubt the efficiency and success of the monohydric system of condensation, I think it might be well to examine some particulars of the process. The quantity of heat to be withdrawn from the apparatus, for each stroke of the piston, is $q\ (650-\theta)$. This, obviously enough, is the same quantity which is carried off by the cold water, which circulates around the exteriors of the tubes of the English surface condensers, and, finally, is also the same as that which should be removed from the condensing water by the refrigeration. In the condensers the transmission of heat takes place by virtue of the difference of temperature expressed by

$(a-b)$, and $a=\frac{\Theta-\theta}{2}$, which is greater than θ.

In the refrigerator this transmission takes place by virtue of $(\theta-b)$. This is a disadvantage, as it reduces the rapidity of the cooling; but it will be largely compensated by the absence of air in the tubes, by the regularity of the process, and by the diminution of scale. In brief, the ratio of one sq. meter per horse power, adopted in England for surface condensers, will be more than sufficient for the refrigerator. Were it otherwise it would be easy to increase this surface until the desired effect be obtained. With respect to leakage in the joints, which has been discussed with reference to the surface condenser, we should find the same difficulty recurring in the refrigerator, but only in an immaterial degree; since, on the one hand, the pipes of the refrigerator would be subjected to much smaller changes of temperature, and on the other, there would be no difference between the interior and exterior pressures. Again, the intromission of gas, which is a serious matter in the surface condenser, is of no particular consequence in the refrigerator.

The presence of a small quantity of sea water in the feed water, far from being an evil, will be beneficial. It would cause a slight incrustation, which would protect the plates against oxydation and the deposit of grease. This would add to the conductibility of the metal, provided the scale remain within the limits previously described.

It has been determined in England that, in engines having surface condensers, there is a corrosion due to the grease brought into the boilers by the feed water. This substance accumulates constantly, producing numerous cavities in the plates, thus shortening the life of the boilers and exposing them to the danger of explosion. The English remedy this difficulty by introducing into the feed water a small quantity of sea-water, which gives rise to a slight protective incrustation of the metal. To this precaution some people add another, viz: omitting to lubricate the piston and slide valve, thus extirpating the evil at its source. This mode of procedure is undoubtedly a great sacrifice. Still, it may be necessary in surface condensation, but it is not so in the monohydric system—a consideration strongly in favor of the latter.

It might be feared that the increase of weight and bulk required by the refrigerator would be a difficulty. But, it will be remembered that the refrigerator is merely a surface condenser with a change of function, and the English have found means of placing in vessels of all sizes surface condensers having more than a square meter of surface per horse power. Their experience for the last four years or more ought to reassure us on that point. We may close this paper with a statement of the following general conclusions: There is great advantage in using steam at high pressures in marine engines. Two methods of its application seem to present themselves: 1st, the surface condenser; 2d, the injecting condenser on the monohydric principle. The injecting condenser is, on principle, much superior to the surface condenser; this superiority is expressed by the ratio of the parts of the resisting work, due to the retardation of condensation, in each apparatus respectively,

$$\frac{Tci-p\ S\ L}{Tcs-f\ S\ L} < \frac{\sigma^2}{\Sigma^2} \cdot \frac{R_s{}^2}{R_i{}^2}$$

R_s and σ being always very small as compared with R_i and Σ.

By the injecting system it is possible to reduce the resisting work of the back pressure to $\frac{1}{4}$ of what it is in the actual injecting condenser, supposing the most favorable conditions; conditions which in the surface condenser are ideal, and can never be realized by reason of the friction of steam in the tubes, the presence of air and of incrustations, which are formed within and without.

The surface condenser consequently is subject to perturbations which may deteriorate considerably, and even counterbalance the advantages of high pressure. The injecting condenser will realize these advantages simply and surely. Hence there is good ground for abandoning surface condensation and employing injecting condensation on the monohydric principle.

AIR IN ILLUMINATING GAS.

From a paper in the "American Journal of Science and Art," "On the effect of Atmospheric Air when mixed with Gas in reducing its illuminating power," by B. SILLIMAN and HENRY WURTZ.

The data given in this article were obtained during an investigation of the Hydrocarbon Gas Process by the "*Gwynne-Harris*," or "*American System*," some notice of the results of which we propose to publish in a future number of this Journal. In the course of this investigation it became important to measure exactly the effect of atmospheric air in reducing the illuminating power of gas. Owing to a mechanical defect in the apparatus connected with the exhauster, it was found that a variable quantity of air had for some time found its way into the gas holder, the influence of which, in diminishing the brilliancy of combustion, was sufficiently conspicuous before the cause was ascertained. The only experiments on this subject known to us when its study was undertaken by us, were those of Messrs. Audouin and Bérard* (also quoted in the American Meter Co's. Pocket Almanac). By these results the ratio of loss in illuminating power by the addition of each one per cent of air appeared to us so enormous, that we were desirous of confirming them. Subsequently we became acquainted with an important paper on this subject by Mr. Carl Schultz,† the main points of which are reproduced in this article; as they appear to have escaped attention, the author having modestly given us only his initials, and the journal in which they appeared being almost inaccessible to scientific readers.

* Ann. de Ch. et Phys., 3d series, vol. lxv, p. 423, 1862.

† American Gaslight Journal, Aug. 1, 1860, p. 41.

In conducting this research we soon found that the attempt to introduce, by measure, a given volume of air into the gas holders connected with the photometric apparatus, was attended with many sources of error, and that the requisite accuracy could be obtained only by the eudiometrical analysis of each successive mixture.* The apparatus employed consisted of two gas holders of ten cubic feet capacity each, connected in such a manner that each could be used independently, or the contents of one transferred to the other and back again to secure a complete admixture of the contents. The air was introduced by opening a stop-cock connected with the interior, and adding weights to the counterpoise, measuring the influx by a centissimal scale of equal parts attached to the drum of each holder. This rude admeasurement was controlled by an analysis of each mixture. This required also the prior analysis of the street gas on each occasion, columns 3, 4 and 5, of the accompanying Table I, show the results of these mixtures as made known by the eudiometer. The illuminating power of each sample was determined by the Bunsen photometer on

* Our labors in this research have been greatly aided by the facilities courteously extended to us by the officers of the Manhattan Gas-Light Company, in New York, who with great liberality placed at our disposal their well appointed experimental laboratory and apparatus at their Eighteenth St. Station.

TABLE I.

DATES.	DENSITIES.		COMPOSITION.			ILLUMINATING POWER.						
Gas of Manhattan Co., N. Y., 18th Street Station, from street mains.	Density of street gas.	Density after air was added.	Air found by analysis in street gas, in 100 volumes.	Air found by analysis after the addition.	Volumes of air added.	Candle power of street gas before addition of air.	Candle power after addition of air.	Candle power of gas alone, air being deducted.	Loss of candle power by air added.	Percentage loss of candle power.	Ratio of loss in candle power in percentage volumes.	Loss of candle power for each one per cent
1869												
March 17..........	401	409	1.96	3.01	1.05	15.12	14.20	14.96	.92	6.08	5.79	.723
" 18..........	392	405	3.15	4.97	1.82	14.67	13.27	14.40	1.40	9.54	5.24	.511
" 23..........	401	424	1.50	3.75	2.25	14.71	12.96	14.37	1.75	11.82	5.25	.582
" 19..........	387	419	1.61	4.61	3.00	14.81	12.49	14.46	2.32	15.69	5.23	.656
" 19..........	387	433	1.61	6.54	4.95	14.81	11.28	13.76	3.53	23.83	4.83	.501
" 19..........	387	467	1.61	13.32	11.71	14.81	8.67	13.07	6.14	41.46	3.54	.419
" 20..........	387	490	1.61	17.79	16.18	14.81	6.29	12.41	8.52	57.53	3.55	.378
" 23..........	403	525	1.12	21.88	20.76	15.09	4.09	11.96	11.00	72.90	3.50	.377
" 20..........	401	551.5	1.61	26.29	24.68	14.11	2.18	10.52	11.93	84.55	3.42	.380
(Gas burned in a 5-ft. 15-hole standard Argand)	1	2	3	4	5	6	7	8	9	10	11	12

the average of fifteen successive observations of one minute each, with the usual corrections. Columns 6 and 7 give these results, and in columns 1 and 2 will be found the corresponding densities determined by diffusion.

Since the air added in each case is rendered *as gas* by the meter during the photometric measurement, it is important to determine the illuminating power of the gas alone after deducting the known volume of air present. The results of these calculations are given in column 8. In columns 9 and 10, the loss of illuminating power is given; in 8, in terms of the candle power lost for each admixture, and in 9, this loss is stated as a percentage. The ratio of loss of illuminating power in percentage volumes of gas and air is given in column 11, and in column 12 is the loss of power corresponding to each one per cent of air added.

The results of the analyses and photometric measurements are more conspicuously seen in the curve projected from columns 5 and 10 of the table upon the annexed diagram, on which the vertical and horizontal scales are as 1 : 3.

The following inferences depend upon the data herein given, viz:

1st. For any quantity of air, less than 5 per cent, mixed with gas, the loss in candle power due to the addition of each 1 per cent is a little over $\frac{6}{10}$ths of a candle (.611 exactly); above that quantity the ratio of loss falls to $\frac{1}{2}$ a candle power for each additional 1 per cent up to about 12 per cent of air; above which, up to 25 per cent, the loss in illuminating power is as shown by column 12 of the table, nearly $\frac{4}{10}$ths of a candle for each 1 per cent of air added to the gas. In column 11 of Table I, the ratio of loss in candle power is given in percentages for the several volumes, while in column 10 the destructive effect of air upon the illuminating power of gas is most conspicuously exhibited, 12 per cent of air destroying over 40 per cent of the illuminating power. In the diagram this loss of power is represented by the numerals in the right hand column, which are inverse to those in column 10, and stand with the maximum intensity = 100.

2d. With less than $\frac{1}{4}$ of atmospheric air, not quite 15 per cent of the total illuminating power remains; and with between 30 per cent and 40 per cent air, it totally disappears.

Now, during December and January the hydro-carbon gas made at Fair Haven had often as much as 12 per cent of air in it; during the month of February the air, by analysis, averaged nearly 9 per cent; while in March, after the separation of the pump from the exhaustion apparatus, the air was reduced at times to nearly nothing. By column 3 of the table it will be observed that the air found by analysis in the street gas, at the Eighteenth Street Station of the Manhattan Gas-Light Co., New York, averaged nearly 2 per cent, and the New Haven city gas contained about the same quantity. We allow, therefore, this quantity (2 per cent) as a normal amount of air in street gas; and, consequently, in the journal of the daily operations with the hydro-carbon process at Fair Haven,* these corrections have been applied; giving in two columns the "corrected candle power," by the addition of the ratio determined in our Manhattan experiments, and the "corrected volume," or yield per pound of coals carbonized, air being deducted." It is obvious that the records of the station meter give the contaminating air as gas, and without the correction thus obtained, the apparent yield is too great.

In large gas-works the liability to contamination by air accidentally introduced from various causes, diminishes in proportion to the total make of gas, and an amount of air which, when diffused in a very large volume of gas, becomes insignificant, if confined to ten or fifteen thousand feet daily product, will become a most serious injury to its illuminating power. This cause of deterioration in gas has been overlooked almost entirely by gas engineers; but in all small gas-works it deserves special attention, and we have no doubt that the low illuminating power, too often obtained in such works, is largely due to this cause.

Results of Messrs. Audouin and Bérard.—We have already alluded to these results, obtained by Messrs. A. and B., which form part of an important memoir published in 1860, under authority of the French Government "upon the various burners employed in gas lighting, and researches on the best conditions for the combustion of gas." Their table, which we append for the sake of comparison, shows "a considerably high-

* *The Hydro-carbon Gas Process.* Report of working results on a large scale under the Gwynne-Harris Patents, Nov., 1868, to May, 1869, by Benjamin Silliman, M. A., M. D., and Henry Wurtz, M. A., N. Y. 8vo, p. 126, printed for private distribution.

er ratio of loss than we have obtained, being rather more than six per cent loss for each one per cent of air added to the gas, reaching a total loss of 80 per cent with 15 per cent of air added; while we obtain 57.53 per cent loss with 16 per cent; and 93 per cent loss with 20 per cent air, while with the latter volume of air added, we get 72.-90 per cent loss. These differences may be accounted for by the French trials being made upon a gas of not more than 12 candles' power, our trials being made on a gas averaging nearly 15 candles. Also, by the fact that in the French experiments the gas was burned from a batswing burner, ours from a standard Argand.

In the experiments of Messrs. Audouin and Bérard, two gas holders of equal capacity were filled, one with standard gas, and the other with the same gas mixed with 1, 2, 3, etc., per cent of air. Each fed a burner of the second class, regulated to a consumption of 140 liters of gas per hour. The illuminating power of the two were compared by making that of the pure gas equal unity. The results are given in the following table, where each figure gives the mean of 6 or 8 concordant observations.

TABLE II.

Showing the results of mixture of air with gas, by Messrs. Audouin and Bérard.

Common Gas.			Gas mingled with Air.				
Intensity.	Size of flame. Height	Size of flame. Breadth	Quantity of air per 100.	Intensity.	Intensity of loss.	Size of flame. Height.	Size of flame. Breadth.
	mm.	mm.				mm.	mm.
100..........	49	92	1	.94	6	43	102
100..........	48	92	2	.89	11	42	100
100..........	49	93	3	.82	18	42	97
100..........	48	94	4	.74	26	42	91
100..........	46	94	5	.67	33	42	96
100..........	45	93	6	.56	44	41	95
100..........	48	93	7	.47	53	40	91
100..........	48	93	8	.42	58	39	94
100..........	46	94	9	.36	64	39	93
100..........	47	93	10	.33	67	38	89
100..........	46	93	15	.20	80	35	86
100..........	45	92	20	.07	93	33	86
100..........	45	92	30	.02	98	26	79
100..........	45	92	40	.01	99	21	60
100..........	45	92	45	....	100	18	47
100..........	45	92	50	....	100	12	24

By this table it appears that the introduction of 6 to 7 per 100 of air, suffices to diminish the intensity by one half, and a mixture of 20 of air with 80 of gas leaves almost no illumination. Unfortunately Messrs. A. and B. do not record the actual illuminating power of their standard gas, which, however, we are led to believe cannot be more than 12 candles of the English and American standard.

We have already alluded to the experiments of Mr. Carl Schultz, and annex below a summary of his results.

Mr. Schultz concludes from his experiments, that the loss of illuminating power due to the addition of air to gas, is about one-half of one candle for each one per cent of air added. He makes the very remarkable observation, that, within limits, the addition of air to *very rich* cannel gas, up to 12 per cent of air, was followed by no loss of illuminating power, but, on the contrary, by a small gain. Thus, boghead cannel gas, giving for 88 per cent gas an illuminating power of 27.47 candles, or for 100 per cent gas 31.32 candles, with 12 per cent of air, gave 28.29 candles, showing that 12 per cent of atmospheric air had increased the illuminating power of the flame by .82 candles. These results are obtained only by the use of an Argand burner. By substituting an intensity burner for the Argand, the results obtained with gas from boghead conform to the rule of half a candle loss for each one per cent of air. (Rev. Mr. Bowditch also states generally, that "impurities are far less destructive of light in Argand burners.")

Mr. Schultz sums up his results in the following propositions:

1st. When coal gas is mixed with atmospheric air, its illuminating power for all 5 ft. burners is reduced in the proportion of half a standard candle to every 1 per cent of air present, except in case of very rich gas burned with a 15 hole Argand.

2d. One cubic foot of atmospheric air will destroy an amount of light equal to 10 English standard candles, during one hour.

3d. This loss being constant, the percentage of aggregate loss will vary with the illuminating power of the gas used.

While our results confirm in general those of Mr. Schultz, in 1860, and of Messrs. Audouin and Bérard, in 1862; it is obvious that the ratio of loss, with equal increments of air added to a 15-candle gas, is by no means constant. The difficulty of obtaining exact results, by the method of mixture of measured volumes is so considerable, especially with quantities below 10 per ct., that the only safe control of the results is that which is obtained by eudiometrical analysis of the several mixtures tested, as was done by us in all cases both before and after the addition of air. It is obvious that the surprising loss of intensity by the addition to illuminating gas of small percentages of air must be owing not merely to the interior combustion due to the presence of oxygen, but still more, probably, to the associated nitrogen, which acts not only as a diluent, or deductive quantity, but its specific heat is an actual *divisory* function in diminishing the flame temperature. The interesting observation, first made by Mr. Schultz, that in very rich cannel gas there is actually an increase of intensity within certain limits due to the presence of oxygen, suggests another series of experiments with successive additions of oxygen to a gas of high illuminating power, which we propose to undertake at our early convenience, as also another series upon mixtures of progressive quantities of carbonic acid.

NOTE.—*Erdmann's Photometer* (*"Gasprüfer"*) depends on the use of air to destroy the illuminating power of gas. Elster has employed this instrument in a series of researches, undertaken to determine the theoretical illuminating power of different materials ("Journal für Gasbeleuchtung," Munich, 1862, p. 384, *et seq.*) After removing the illuminants by sulphuric acid, he found that ordinary illuminating coal-gas required 150 volumes of air to destroy completely the yellow flame of 100 volumes of gas. If the amount of light obtained by the addition of one per cent of olefiant gas to the decarbureted gas employed in a definite burner, is called *one candle*, it was found necessary to add 6.5 per cent of air to destroy the illuminating power of this gas containing one per cent of olefiant gas, or to destroy one candle power. As a like quantity of carbon, carried to a white heat, produces always, in a gas burning from the same burner, the same quantity of light, and it requires the same quantity of air to transform it into carbonic acid, we may regard an ordinary 12-candle gas as a mixture of an unknown non-luminous gas, holding in suspension during combustion a quantity of white-hot carbon, equivalent to 12 per cent of olefiant gas, and requiring, consequently, a quantity of air equal to 210 volumes for 100 volumes of gas ($88 \times 1.5 + 12 \times 6.5 = 210$). Each additional candle power requires an addition of 5 volumes of air, as the constant indicated by these results of Elster. [*Translated from Schilling, French Edition of* 1868.]

In the use of the Erdmann apparatus, it is found that the volume of air required completely to destroy the illuminating power of coal-gas ranges from 188 to 245 volumes per 100 volumes of gas, varying with its richness.

These results, it will be observed, harmonize in a satisfactory manner with those obtained by us, as embodied in Table I.

Every chemist will at once recur, also, to the action of air upon gas in the Bunsen burner, in constant use in all laboratories provided with gas—an instrument identical in principle with the *Gasprüfer* of Erdmann.

STEEL RAILS.—Certain tests of the ductility of steel rails are about to be instituted at the works of the New York Central Railway, at West Albany. We will try to give our readers the result in our next issue.

THE MECHANICAL VENTILATION OF MINES.

By MR. WILLIAM COCHRANE.

Abstract of a paper read before the Institution of Mechanical Engineers at Newcastle.

It must be admitted that in the great advance which has been made in the development of mining enterprise, and looking to the future requirements of our local coal fields, adequate ventilation is not inferior in importance to any of the problems which the mining engineer has to solve. The earliest records of mining make us acquainted with the readiest mode of ventilation, no provision beyond the natural conditions being adopted; and so long as mines were only worked to a very limited extent by levels or "adits," and if by shafts, of very small depth, the natural system was found to answer all requirements; only there was this disadvantage — that, with thermometrical variations, the determination of the current of air was dependent on the average temperature of the mine being above or below that of the external atmosphere, a condition constantly varying and interchaning throughout the year, and therefore not permitting any certainty of action in the direction or quantity of air which can be used for ventilating the mines. This system is still used in mines of limited extent, and where, from the nature of the mine, very small resistances are offered to the current of air circulating. In some cases, under these conditions, as in the Staffordshire "thick coal" mines, the determination of the air into a particular course is often ensured by placing a fire lamp in the upcast shaft. Such a contrivance, however, can only produce a very small effect, and is therefore of limited application. On a larger scale, however, this principle has formed the most generally adopted system of mine ventilation in this country, namely, that of the furnace. This paper then described the system now most generally in use, and went on—Much discussion has arisen as to the best system of furnaces and the most economical mode of feeding them with air. The following were the results of some recent experiments that had been made at different collieries in the northern coal fields under various conditions and depths of shafts, extent of workings and thickness of the seams of coal, and were reduced for the purpose of comparison to the duty that one pound of coal consumed, effected per horse power on the air circulated in the mine, the pressure being indicated by a water gauge placed in the mine, and therefore representing only the work done in overcoming the friction down to the mine, and exclusive of the work required to overcome the friction resistance of the two shafts. The general result of the experiments was that that duty varied from 37 lbs. to 101 lbs. of coal per horse power on the air taken upon currents of air ranging from 40,000 to 120,000 cubic feet per minute. Depth of shaft, it is said, is the most important consideration for the efficient application of a furnace. There are other conditions, however, which it is necessary to secure, namely: that the shaft be dry, and that it be lined with a good heat-retaining material. It is considered a fair estimate of the economic value of the average conditions in which furnaces are worked that only five degrees of the heat due to the combustion of the coal are utilized. There are many objections, besides the small useful effects in the use of the furnace, which cannot be overcome, and which form a constant source of cost attendant upon it, namely: the necessity of cleaning the flues and the consequent suspension of the active ventilation of the mine; the inconvenience, and in some cases the impossibility, of using a shaft highly heated and often full of smoke, for any other purpose than as a ventilating shaft, and the serious damage done to cast-iron tubing, timber, pumps or wire ropes, where winding is carried on in the up-cast shaft by the products of combustion, especially where the shaft is damp. If the conditions are unfavorable for the use of a furnace—such as shallow shafts and heavy resistances to be overcome—the furnace is then quite unable to compete with a good mechanical ventilation for economical effect. The limit of the furnace as a ventilating power is soon reached where the resistances offered by a mine are heavy; and this objection materially led to the adoption of other means to meet the conditions under which the furnace would fail to afford a sufficient ventilation. Machines for blowing fresh air into or exhausing the foul air from mines were adopted in the very earliest times, especially abroad, where the conditions of the seams are such as required more efficient means than the furnaces supplied. Hence it is that mechanical ventilators are very numerous abroad, while in this country, until very recently, they were quite exceptional. In a table compiled by Mr. J. J. Atkinson, Government Inspector for the Durham coal field, has been shown the depth at which furnaces are estimated to be equal to ventilating machines in point of economy of fuel, assuming that the sources of loss are of the same extent in each case; that is, the loss of fuel in furnaces by cooling in the upcast, and in ventilating machines the power expended in overcoming the useless resistances, and that the ventilating machines utilized 60 per cent of the engine power. The general result is that the minimum depth at which the economy by the two plans is equal is 960 yards, with an average upcast temperature of 100° Fahr., and a depth of 1,130 yards with 200° Fahr. temperature, estimating a consumption of 8 lbs. of coal per hour per indicated horse power of the engine. A recent calculation by M. Guibal, of Mons, deduces the following comparisons: that if a furnace in a 12 ft. shaft, 400 yards deep, circulate 53,000 cubic feet of air per minute under the total resistances represented by $3\frac{1}{3}$ in. water gauge, and an average excess of upcast temperature of 108° above the downcast, with a duty of 31 lbs. of coal per horse power in air estimated upon the total resistances—a mechanical ventilator utilizing 60 per cent of the power employed would, under the same conditions, have a duty of 11 lbs. of coal per horse power in the air, being a saving of 64 per cent. At a depth of 550 yards to circulate the same volume, the duty of the furnace being 22 lbs. of coal, that of the mechanical ventilator would be 11 lbs., being a saving of 50 per cent. The paper then classified the mechanical ventilators which had been used under two heads—first, those working by centrifugal action; and, second, those working as pumps. Of those of the first class, one had been described at the last meeting—the Guibal ventilator, at Crudley Colliery, Staffordshire. The largest example, it went on, of that class erected in this country will be seen at the Thrislington Colliery. It is 36 ft. diameter and 12 ft. in breadth, driven by a horizontal cylinder 30 in. diameter and 30 in. stroke. This ventilator has only been recently erected, and is not yet ventilating any large extent of working, but some experiments have been made with it, from which the following results have been obtained. The regulating shutter was not properly adjusted so as to give the best results of working, and the drift to the upcast shaft was too small for accurately increasing the current of air, amounting to 80,000 cubic feet per minute. With 54 revolutions per minute a water gauge of $2\frac{1}{2}$ in. was maintained at the inlet; with 70 revolutions a water guage of $4\frac{1}{2}$ in., and with 80 revolutions a water guage $6\frac{1}{4}$ in. After giving the results of other Guibal ventilators in operation, the paper continues: In order to make a fair comparison of the Guibal ventilator with the furnace, the following case of the Pelton Colliery, Durham, is given, as it is the only one where the data have been accurately ascertainable respecting the replacing of the furnace by this mechanical invention. In this case the duty obtained by the furnace was 102 lbs. of coal per hour per horse power in the air estimated, on the water gauge of $\frac{1}{10}$ in. indicated in the mine, and a current of air of 35,000 cubic feet per minute; and the duty was reduced by the ventilator to 20 lbs. per hour per horse power with a current of 54,000 cubic feet, and a water gauge of 2 in. indicates in the same position. This shows a saving of fuel by the adoption of the Guibal ventilator in place of the furnace, amounting to 80 per cent. The class of ventilators to which the Guibal belongs is that of centrifugal action, and in the same class may be mentioned the Biram, Nasmyth, Brunton, Rammell and Waddell ventilators. [Diagrams of the Nasmyth, Rammell and Waddell ventilators were exhibited.] A Biram ventilator (similar in principle to the Nasmyth, with the exception of the vanes being inclined to the radius) the writer has experimented upon at Tursdale Colliery, Durham, and found that only $12\frac{1}{2}$ per cent was utilized of the gross power supplied from the steam boilers; and from experience with other open running fans, he considers that percentage cannot be materially exceeded with any form of open fan without a casing. A Waddel ventilator, recently erected at Pelton Colliery, utilizes only 39 per cent of the power applied; and a Rammell, at Framwellgate Moor Colliery, does not exceed 40 per cent of utilized power. The Guibal utilizes 60 per cent of the power applied. Except the Guibal, all the other ventilators of this type discharge throughout the entire circumference; but that this is a defect can be inferred from the fact that if such a fan running open have the access of air into its center stopped, great power will still be required to make it revolve, though no useful work is done. The useless work done upon the external air in this case is done to a diminution of useful effect, when the fan is exhausting air supplied at its center from any mine drift or passage. It was anticipated that the Waddell ventilator would obviate this defect by arranging the air passages through fans of a gradually decreasing section from the center to the circumference, so that the velocity of rotation at any point multiplied by the sectional area of passage at that point should be constant, thus filling up the fan with the issuing air, and preventing the possibility of re-entries. In this case the re-entries cannot be seen as in the Biram, where the eddies of air all round the circumference are easily distinguished, but that they do evidently arise is proved by the lower power utilized. The Brunton, which closely resembles the Waddell and the Rammell, cannot be expected to yield any better results. By the kind permission of Mr. Daglish, the results of a Rammell ventilator, recently erected at the Framwellgate Colliery, are here given: diameter of ventilator 22 ft., with 20 in. steam cylinder and 102 revolutions per minute; volume of air 53,600 cubic feet per minute, with a water guage of $2\frac{1}{8}$ in.; result, 40 per cent utilized. One of the chief reasons of the low useful effect of these exhausting fans is that they are exposed throughout the entire circumference to the external air, which rushes in behind the vanes to supply the vacuum formed by their revolutions; but this vacuum ought to be supplied only from the mine to be ventilated, and it was this consideration, and the practical proof that this injurious effect was inherent in open running fans, that led to the casing of the Guibal ventilators, and discharing the air at only one part of the circumference. This step, however, was attended with the objection that the air was discharged with a high velocity, viz: the velocity of the periphery of the fan, and carried away with it a most important store of force, the partial utilization of which has been effected by adapting the principle of *evased* tubes to the expanding chimney, in which the casing of this ventilator terminates. The air entering its base at a high velocity, leaves the chimney at a reduced velocity proportionate to the increased area of the outlet, and in this action restores a considerable amount of power it would otherwise carry off. An adjustable shutter was next found necessary, in order to regulate the size of the outlet and the various conditions of the volume of air required and resistances. A series of very interesting experiments had been made, showing the steadily improved results obtained from the ventilator, as the casing chimney and shutter, in its accurate adjustment, were consecutively added. Generally, as to the powers supplied from the steam boilers for working these ventilators, 60 per cent was found to be utilized; but it must be noted that this amounted to at least 80 per cent of the power actually transmitted to the ventilator, as one-fourth of the boiler power must be allowed for the loss due to the friction and imperfection of the steam engine. One of the ventilators (of which several examples were now in use in this country of 36 ft. diameter) had been recently started in Belgium of 40 ft. diameter, but detailed experiments had not yet been made upon it. It was arranged to work at the speed of 80 revolutions per minute, producing a ventilation of 150,000 to 200,000 cubic feet of air per minute, under a depression of the water gauge of about 7 in., which was certainly the maximum requirements of any known condition of mines. Indeed there could be no question that any practical requirement in the ventilation of mines could be satisfied by this system, and it could not be surpassed in simplicity of construction, small liability to accident, and the little wear and tear to which its working parts were subject. The paper next pointed out the peculiarities in the Guibal ventilator—as to the concentric form of the casing and as to the curving of the vanes—and it then dealt with the second class of mechanical ventilators—that in which the principle of variable capacities, as in the pump, was involved. Struve's air-pump ventilator was the best known of the class, and consisted of two gasometer-formed pistons working in rings of water, alternate upward and downward strokes drawing air from the mine, and forcing it into the atmosphere by means of suitably arranged valves. The Struve was, when well constructed and in good order, capable of producing a very satisfactory exhaustion, but for certain reasons it did not offer the advantages for mine ventilation which the centrifugal action fan did. The useful effect was from 40 to 45 per cent of the boiler power, when all the working parts, and especially the air valves, were in good condition. In conclusion (to quote the words of the paper) the economy of fuel, if neglected hitherto, has now become of paramount importance. To increase the amount of air in any given time, the mine requires the consumption of an increased quantity of fuel, proportionate to the cubes of the volumes; thus, for twice the volume eight times the fuel. Hence the best system of ventilation is that which, under the same conditions of mine and the same amount of first outlay, produces the maximum work for one pound of coal consumed, so long as such ventilation compares satisfactorily with any other in the points of durability and cost of working, and possesses the quality of adaptability to all the varying conditions which are met with in mining operations.

TESTS OF STEEL RAILS.—Messrs. John A. Griswold & Co.'s circular thus describes their method of testing steel rails:

"1st. A test ingot from each five-ton ladleful of liquid steel is hammered into a bar, and tested for malleability and hardness, and especially for *toughness*, by bending it double cold. In case any test bar falls below the standard established as suitable for rails, all the ingots cast from that ladleful of steel are laid aside for other uses.

"2d. All the ingots, and each rail rolled from them, are stamped with the number of the charge or ladleful. A piece is cut from one rail in each charge, and tested by placing it on iron supports a foot apart, and dropping a weight of five tons upon the middle of it, from a height proportioned to the pattern of rail. A blow equivalent to a ton weight falling 10 to 15 ft. is considered a severe test. We use a five-ton weight falling from a less height, believing that it more nearly represents in kind (although it of course exaggerates in severity) the test of actual service in the track.

"In case a test rail does not stand the blow deemed proper and agreed upon, the whole of the rails made from that charge or ladleful of steel are marked No. 2, and sold for use in sidings, where their possible breaking would do no great harm, and where their greater hardness and resistance to wear would be specially valuable.

"In addition to this double test, the rails are rigidly inspected for surface imperfections.

"We believe that these tests render it practically impossible for us to send out rails of inferior quality.

"We farther invite railway companies to send inspectors to our works to witness the tests mentioned, and other tests and inspections agreed upon."

THE ELLERSHAUSEN PROCESS.—We give elsewhere some interesting details. In a future number we shall describe a modification which will prove of still greater interest.

BOILER EXPLOSIONS.

From a paper on "Government action with regard to Boiler Explosions. A statement of various plans for the object of discussion." Read before the British Association by Mr. LAVINGTON E. FLETCHER, C. E.

It is not in accordance with the rules of the British Association for Reports presented by Committees appointed to investigate and report on certain subjects, to be discussed in the meetings of the Sections. There are circumstances, however, at the present time, that render it especially important that the opinion of the members of the British Association should be fully expressed on many of the questions touched on in the report just read relative to Coroners' Inquests and Steam Boiler Explosions. The Home Secretary stated in his place in the House of Commons very recently that he would do his utmost, in the recess, to prepare a measure for the suppression of steam boiler explosions, so that it is of great importance that suggestions from all parties should be invited on this subject, and that the various plans proposed should be fully considered, so that the whole question may be well sifted. Under these circumstances I have, under the advice of one of the Secretaries of the British Association, prepared a brief secondary paper, on which it will be in order to raise a discussion. After the Report already presented to the Association, relative to Coroners' Inquests and Boiler Explosions by the Committee appointed to undertake that duty, I need do nothing more in this paper than name the points on which it is desired to obtain the views of the members of the Mechanical Section of the British Association.

The constant recurrence of boiler explosions, and the number of lives annually sacrificed therefrom, has aroused public attention to this subject. The public begin to suspect that these disasters are not so accidental as it has for a number of years been attempted to make out, but that they might, after all, be prevented. The system of periodical boiler inspection has proved itself sufficient to accomplish this task, and therefore the public naturally ask—why do not all steam users have their boilers inspected, and if they neglect this simple precaution, which has now been adopted by so many for the last fourteen years, why should not the law step in and compel them to adopt it?

This, therefore, opens the first question, whether it is expedient or not for the Government to interfere in the matter of the prevention of steam boiler explosions, and if so, in the second place, what would be the best mode in which the Government action should be taken. In answer to this second inquiry there are at least three plans now before the public, of which a brief outline may be given.

One of these plans is that the Government should take the supervision of every boiler in the country, with the exception of locomotive and marine, and through the medium of the Board of Trade should test all new boilers, and periodically examine them when set to work, as well as all others already in use, the examinations being made both when the boilers are at rest, as well as when at work with steam up.

All Englishmen have a strong dread of Government interference, and of the introduction into this country of the continental paternal system, fearing lest it should hamper progress and fetter individual action. This measure therefore is one which, to say the least of it, is calculated to provoke considerable opposition.

Another plan is, to render inspection compulsory, but not that the Government should take the task of examining boilers into its own hands, that is to say, it is proposed that no steam user should be allowed to work a boiler that had not been examined and certified as safe by some local inspection association or insurance company, duly authorized by the Government as competent to the task.

This plan has certainly less of the air of the continental paternal system about it, and appears more adapted to the usages of this country, though it by no means appears to be free from difficulty in its application. It is important that the integrity of the inspections should be preserved, and it may be well to suggest for consideration, whether there might not be a difficulty in securing this if the question of deciding on the safety of all the boilers in the country was handed over to a number of competing joint stock companies. Joint stock companies clearly exist for the sake of dividends, and it is difficult to see, if they are to be paid by steam users for granting certificates for the safety of their boilers, how the integrity of those certificates could be secured under a pressure of competition for business. Judges, to be impartial, should not be remunerated by those whose cases they have to adjudicate, more especially if their payment depends on giving satisfaction. It is feared that under such a system, inspections might grow lax, and that the sale of certificates would soon be not unlike the sale of indulgences in days gone by. It is therefore a point for discussion how far it would be wise to commit the safety of all the boilers in the country to the charge of commercial competing companies intrusted with the monopoly of the sale of boiler certificates. Possibly there may be some way of meeting this difficulty, but it was thought well to throw it out for discussion on the present occasion.

A third plan is that every steam user should be left perfectly free to lay down what description of boiler he may think best, and to enrol it or not, either with a Boiler Inspection Association or Boiler Insurance Company as he sees fit, and, indeed, that he should be free to do just what he likes as long as he does not burst his boiler, but in the event of explosion it is proposed that the Government should then step in, make a most searching investigation of the facts, and publish the information for the benefit of the community at large. On this system the steam user would be left perfectly free in his choice of means, but would be held responsible for results, and, in the event of explosion, would be open to a claim for damages from relatives of those killed by the failure of his boiler. This plan, it is argued, would act preventively, inasmuch as it would, it is hoped, arouse to suitable vigilance all those connected with the use of steam, which is all that is required for the prevention of steam boiler explosions.

These are three of the principal plans now before the public. The first proposes to act on the paternal system, and to take every boiler under the Government wing. The second does not propose that the Government should undertake any inspections itself, but that it should leave them to duly authorized local associations, rendering it, however, compulsory that the steam user should avail himself of one or the other of these organizations. The third plan goes on the principle of believing every man innocent till he is proved guilty, and of punishing offenders in the hope that by so doing a repetition of the offense by others will be prevented.

Such is a brief recapitulation, and but little more, of the measures now before the public, while the few suggestions that have been added to this brief recapitulation have been thrown out more to stimulate discussion than by way of advocacy in the case of either plan, and full discussion is now invited on these questions from the members of the Mechanical Section of the British Association.

ON CANTING RAILS.

By W. Airy.

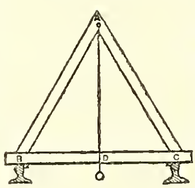
From "The Engineer."

It will generally be found on railways that the amount or cant on curves which the outer rail receives is considerably less than the theoretic cant due to the highest ordinary speed maintained on the line. Nevertheless it is maintained in works on civil engineering that the full maximum cant which the formula demands ought to be insisted upon. Now, when experience has led to a universal system of departure from theory, it may safely be affirmed to be practically correct, and the writer had abundant opportunity of investigating the question. There are two important reasons why the cant should be kept under rather than over the cant due to the highest ordinary speed on the line. First, because a train goes more steadily round a curve when bearing constantly and firmly against the outer rail; and secondly, because when bearing hard against the outer rail, the coning of the wheels assists the motion round the curve. Now, with regard to the first of these reasons, it is well known that nothing tends so much to make engines run off the line as allowing play between the rails. So long as the wheels run steadily and closely between the rails, the train is safe, and it would require a vast force to make it leave the metals; but when the engine has leave to play between the rails, it begins to roll and oscillate from side to side, and has a tendency to mount the rails and leave the line. So well is this known that at crossings, where great steadiness is required to avoid injury to the points of the crossing, it is customary to reduce the gauge to the extent, in some cases, of ⅜ in. Now, on a curve, if the cant be not too great to permit it, the centrifugal tendency will ensure the steady bearing of the wheels against the outer rail, and the train will run steadily round; but if the cant be rather too large for the speed, the engine will acquire a violent oscillatory motion—it will fall off from the outer rail and come upon the inner; then in consequence of the inequality of the lengths of the outer and inner rails, aggravated in this case by the coning of the wheels, it will be thrown back upon the outer rail, and so on. The above would, of itself, form a very sufficient reason for keeping the cant less than that due to the highest ordinary speed on the line; but if the wheels are coned as they usually are, it would seem quite suicidal to cant the rails so much as to throw the pressure upon the inner rail; for then the larger circumference of the wheel would be running upon the inner rail, and consequently upon the shorter curve; the engine would in consequence receive a violent twist and be thrown against the outer rail with its front not tangential to the curve, but sensibly inclined to it, and the tendency to mount the rails would be very great. For both the foregoing reasons it would appear advisable in all cases to keep the cant rather below than above that due to the highest ordinary speed on the line, and the practice of engineers in so adjusting the cant is fully justified.

There is a special difficulty in correctly applying the cant at the commencement of the circular curve. The reason is that the curve commences abruptly, and so, in consequence, ought the cant to commence abruptly. When an engine passes off a piece of straight upon a circular curve, it is suddenly exposed to the full centripetal force due to that curve; the effect of this is to give the engine a sudden jerk, similar to a blow, and tending to twist the engine round in the direction of the curve. The effect of this twist, however, remains unbalanced, and prevents a repetition of such shocks as the engine passes along the curve; and if the rails be not overcanted the motion is as smooth as on a piece of straight. But it is impossible to apply the cant suddenly, as the curve is applied; and to apply the cant gradually on the piece of straight leading up to the curve would have the dangerous effect of making the engine roll and oscillate as already described. So that there seems to be no proper remedy for this inconvenience, except by flattening the curve at the commencement, either by eye, in the manner of platelayers, or by the use of easier and more gradual curves than the circular curves which are usually adopted.

There is an important question suggested by the numerous girder bridges on the Charing Cross Railway. Some of these, at Southwark-street and London Bridge, are on sharp curves, and the question arises, Ought not the girders that carry these bridges to be canted? Evidently they ought. The girders are subjected to two forces: one a vertical force due to the weight of a train, the other a horizontal force due to the centrifugal force of the train on the curve. The combination of these two forces give rise to a resultant force inclined to the vertical, and the girders, in order to meet this force fairly, should be also inclined to the vertical. This inclination is by no means insignificant in amount; it corresponds, indeed, to the inclination of a straight edge laid across the rails to the horizontal, when the rails are properly canted; and this on a girder 12ft. high would appear very considerable. Without, however, insisting upon the full inclination due to the centrifugal force, it is quite certain that a considerable degree of cant might be advantageously applied to the girders on curves; and it is, at all events, to be borne in mind that if a girder be not canted at all, or only moderately canted, an engine passing along the curve at a high rate of speed puts a far greater strain upon the girder than if it passed at a slower rate; and this strain attacks the girder in its weakest point, viz: its tendency to buckle. Such girders should, therefore, be amply stiffened by lateral plates and angle irons.

It is often necessary to check the amount of cant which the platelayers have given on different curves along a considerable length of railway, and for such purposes it is useful to have an instrument adapted to the rapid measurement of the cant. The writer adopted the following method:—A B C is a symmetrical triangular framing of strong wooden laths; B C is the gauge 4ft. $8\frac{1}{2}$ in.; and A D, the perpendicular from A upon B C, is also 4ft. $8\frac{1}{2}$in. From the point A is suspended a plumb-bob, and the rod B C is graduated both ways with inches and parts starting from the point D as zero. Thus, if there be no cant on the rails, and, consequently, their tops are at the same level, the plumb-line cuts B C at the zero point D; and if the rails are canted, then, since A D is equal to B C, the deflection of the plumb-line in inches from D will be equal to the cant on the rails, and the cant can be read off rapidly from the rule itself.



THE REPORT of the State Engineer of New York on Railways, is just out.

THE RESISTANCE OF ARMOR PLATES.

A paper on the Penetration of Armor Plates with Long Shells having Large Bursting Charges, fired obliquely, read before the British Association, by JOSEPH WHITWORTH.

At the meeting of the British Association at Norwich last year, I contributed a paper to the Mechanical Section "On the Proper Form of Projectiles for Penetration through Water." This paper was illustrated by diagrams showing the effects proper on an iron plate, immersed in a tank of water by projectiles with flat-hemispherical and pointed heads.

In that paper I claimed for the flat-fronted form of projectiles made of my metal three points of superiority over the Palliser projectiles adopted in the service.

1. Its power of penetrating armor plates even when striking at extreme angles.
2. Its large internal capacity as a shell.
3. Its capability of passing undeflected through water and penetrating armor below the water line.

This latter feature was, I think, satisfactorily proved by the experiments described last year, and I now desire to draw the attention of the section to the experiments I have made for illustrating the penetrative power of long projectiles with the flat front, fired at extreme angles against iron plates.

These experiments are illustrated by the projectiles actually fired, and the plates they penetrated, which are laid on the table.

The gun from which all the projectiles were fired is called 3-pounder, though capable of firing much heavier projectiles; it weighs 315 lbs. and the maximum diameter of its bore is 1.85 in.

The charge of powder used in all cases was 10 oz., and the weight of the 6 diameter projectiles is 6 lbs.

No. 1 is a portion of a plate 2 in. thick, penetrated by the 6 diameter flat-fronted projectile, at an angle of 35°.

No. 2 is a similar piece of plate 1.7 in. thick, completely traversed at an angle of 45° by the flat-fronted projectile No. 2, which buried itself to a depth of 30 in. in a backing of iron borings.

No. 3 is a piece of plate 1.75 in. thick, penetrated at an angle of 65° by the flat-fronted projectile No. 3.

No. 4 is a plate 1.7 in. thick, nearly penetrated at an angle of 45° by the $3\frac{1}{2}$ diameter flat-fronted projectile No. 4.

No. 5 is a plate $1\frac{1}{2}$ in. thick, against which the *pointed* projectile No. 5 was fired at an angle of 45°. The projectile failed to penetrate the plate, being deflected by the pointed form of bend; the distortion of its shape shows the force with which it struck the plate, and proves the excellent quality of the material which could resist such a test.

No. 6 is a plate also $1\frac{1}{2}$ in. thick, against which a Palliser projectile $2\frac{1}{4}$ diameter long made of Pontypool white iron, with the *pointed* form of head, has been fired; the projectile has scooped out a furrow 4 in. long and $\frac{7}{10}$ in. deep. It broke up into fragments.

The plates Nos. 1 and 3 were purposely thicker than the projectiles could quite pass through, in order that the "work" of the projectiles might be as severe as possible; an examination of the projectiles themselves will show how well they have withstood the severe strain to which they have been subjected.

The data thus obtained fully establish, I think, the superiority I claimed for the flat-fronted projectiles made of my metal, and satisfactorily prove:

1. That the flat-fronted form is capable of piercing armor plates at extreme angles.
2. That the quality of the material of the shell enables their length to be increased without any risk of their breaking up on impact, and thus increases their capacity as shells.
3. That this increase in length, while adding to the efficiency of the projectile as a shell, in no way diminishes but increases its penetrative power.
4. That the amount of rotation I have adopted in my system is sufficient to insure the long projectile striking "end on," and thus to accumulate the whole effect of the mass on the reduced area of the flat front.

These experiments show, further, that the Palliser projectiles fail to penetrate when striking at an angle, solely on account of the form of the head; the Whitworth projectile, which resisted the shock and did not break up, being deflected in precisely the same manner as the Palliser projectile which was shivered into fragments.

The objections I made in my paper last year to the Palliser projectile—1st, that its form of head causes it to glance off, and, 2d, that the brittleness of its material causes it to break up on impact—I have now proved to this section.

The facts illustrated by these experiments are not of recent discovery. Ever since 1858, I have experimented upon and advocated the flat front. I have on the table a small plate, ½ in. thick, experimented upon in 1862, with hardened steel bullets fired from my small-bore rifle. No. 39 is the hole made by a flat-fronted bullet, which has penetrated the plate at an angle of 45°. No. 40 is the indent of a hemispherical headed, and No. 40 of an ordinary round-nosed bullet, both fired at the same angle of 45°. These three rounds were fired in 1862.

Within the last few days I have had a Palliser shaped bullet fired on the same plate at the same angle, in order to compare the effect produced on a larger scale on plate No. 6. It is interesting to observe how closely the effects obtained with the small calibre of the rifle agree with those of the 3-pounder gun, which form the subject of this paper.

These experiments were made with a gun of small calibre from considerations of economy and convenience, but I have always found that what I could do with the smaller calibres of my system could be reproduced in the larger sizes, and from my past experience I feel warranted in asserting that the effects of penetration now exhibited could be repeated on a proportional scale with my 9 in. guns at Shoeburyness, or with 11 in. guns my firm are now engaged in constructing.

A glance at the formidable nature of the projectiles thrown by these guns, and a consideration of the effects they may be expected to produce, will show the importance attaching to the question of penetration of plates by long projectiles.

The 9 in. guns, to which I have referred, weigh 15 tons each, and are capable of firing powder charges of 50 lbs.

A 9 in. Armstrong shell, five diameters long, weighs 535 lbs., and will contain a bursting charge of 25 lbs.

I have no hesitation in saying that these projectiles would pierce the plated side of a ship, at a distance of 2,000 yards, and at some depth below the water line.

The 11 in. guns will weigh 27 tons each, and will be capable of firing 90 lbs. powder charges.

The 11 in. shell, five diameters long, will weigh 965 lbs., and will contain bursting charges of 45 lbs., and would pierce the side of the ship Hercules, plated with 9 in. armor, at a distance of 2,000 yards.

Were it not that the increased destructiveness of war must tend to shorten its duration and diminish its frequency, thus saving human life, the invention of such projectiles could hardly be justified; but believing in the pacific influences of the most powerful means of defense, I have named these long projectiles the "*Anti-war*" shell.

The principle I have always insisted upon, and laid down for my own guidance in artillery experiments, when either a low trajectory or penetration is required, is "*that every gun should be capable of withstanding the largest charge of powder that can be profitably consumed in its bore.*"

I have drawn up a table of the sizes of the bores of my guns, with their proportionate powder charges, and can undertake that they shall be fully equal to this duty, and realize the highest possible consumption for a given quantity of powder.

But the guns adopted in our naval service are not equal to such a test, nor, as I believe, are they so proportioned as to realize the best effect from the quantity of powder they consume.

Four guns of 12 in. bore have lately been put on board the Monarch; they weigh 25 tons each, and fire charges of from 57 lbs. to 67 lbs., and projectiles of 600 lbs. weight. I have no doubt that these guns have been made with all possible care, and are as strong as their material and construction admit of their being; but if the weight of these guns was in proportion to the capacity of their bore, and the material were the best that our metallurgical skill could supply for such a purpose, they ought to fire 117 lbs. of powder, and projectiles of 1,250 lbs. weight. These would then be indeed efficient weapons, but at present they are more formidable in name than in reality. We are often flattered by being told that we have the best guns in the world. That may or may not be the case; but I think we should not rest contented while we are still so far from having attained all that our present advancement in mechanical and metallurgical science has rendered possible to us.

IRON RAILS.—We hope to be able to present to our readers in the next number, a *proof*, drawn from the experience of one of our leading railways, that good iron rails can be produced by paying a reasonable price. There purports to be a doubt on this subject in the minds of our railway managers, but we believe that they have not had an opportunity to familiarize themselves with the facts—and these we hope to present in convincing shape.

IRON AND STEEL NOTES.

The Pomeroy Patents.—The Pomeroy Patents Company possess the following patents for the improved manufacture of Iron and Steel:

1st. For the smelting and refining of Iron in the blast, cupola, puddling, or other furnaces, by the combination of hydrogen in the shape of steam or water, with Franklinite or zinciferous ores.

2d. For the manufacture of cast-steel from the refined iron.

3d. For a hot air double reverberatory furnace for the manufacture of steel or balling up steel sponge.

4th. For a desulphurizing, deoxidizing and carbonizing furnace for making steel sponge.

5th. For an improved method for manufacturing imitation Russia Sheet Iron.

6th. For covering iron with copper or other metals, such as bolts, spikes, nails and sheets.

7th. For movable grate bars for the steel and sponging furnaces, so as to keep the grates clean without opening the doors.

The great advantage of the hydrogen process for the purifying of iron has been abundantly proved. But the chief object since the foundation of the Company has been to demonstrate their steel patent for making steel suitable for rails. For this purpose they erected a furnace at Newark, N. J., which proved of remarkable power, melting old iron rails, refining, carburizing into steel, and casting the ingots in from $2\frac{1}{4}$ to $2\frac{1}{2}$ hours from the time of charging the old rails. Some very fine ingots of steel were produced, which were proved and tested in Philadelphia, to be of superior quality. The work was done in the presence of many experts and other parties, who all expressed themselves satisfied with the results. The irregularity of the old rails and the difficulty of getting a material for the bottom of the furnace to stand so great a heat, were the principal difficulties encountered; but the managers are fully persuaded that these objections will be overcome and the process become a success when a new and improved furnace is erected and a material proper for lining obtained. While making these trials, parties applied to have steel sponge worked in the furnace to try to convert it into steel direct. After many trials it was found to be impossible on account of the great quantity of slag made from the sponge; but it was found that the furnace had superior powers for extracting the iron and that it could then be rapidly balled up into malleable iron, requiring only hammering to make superior blooms for converting into steel, rolling into rails, or other purposes.

The result being so satisfactory, the next requisite was to get a sponging furnace that would do the work thoroughly, expeditiously and cheaply. In this the managers think they are successful, having reduced the time of sponging the crushed ore to about 3 hours, or working continuously 3 heats in 24 hours. This process formerly required ten to twelve days, and the time has been gradually shortening. With improved furnaces, they will be able to reduce the time to six hours, or 6 heats in 26 hours. By these improvements the manufacture of rails can be reduced from $10 to $15 per ton, according to facilities for obtaining coal and ore. The quality will also be very superior to the iron now used for rails, and by proper care in balling up, a small percentage of carbon may be left in the bloom to form the head of the rail, thus making it but little inferior to a steel headed rail. Another great advantage, and a very important one is that the expensive blast furnace will be dispensed with, and works to turn out an equal quantity of blooms, can be erected for about half the cost of furnaces to turn out an equal quantity of pig iron. The furnaces are all so simple in construction and working that there is no great risk of any serious accidents, and only a moderate degree of wear and tear; thus avoiding the great peril of blast furnaces; also the time for erecting works to make blooms, would not be but half the time required to erect blast furnaces. At the experimental works at Newark, magnetic 60 per cent ore has been worked. The balls made were hammered and rolled at Trenton, into a rail 28 feet long, 68 lbs. to the yard, weighing 626 lbs. This rail has been pronounced by all who have seen it, as of superior quality and finish. A piece of the head from the waste end of the rail, has been tested by Whitney & Sons, Philadelphia, for tensile strength, as follows:

No. 1, piece tested	66,712 lbs.,	per square inch.
2, "	66,850 "	" "
Average,	66,780 "	" "

This is 25 per cent stronger than common rails, and ten per cent stronger than the standard for bridge iron.

The ore was good, but had $1\frac{1}{8}$ per cent of sulphur and $\frac{1}{2}$ per cent of phosphorus in it, and yielded 50 per cent in the balls. The great strength is mainly due to the fluxes used in the sponging and balling, together with the use of hydrogen and Franklinite, which eliminate the impurities and make a neutral iron; being so pronounced by an experienced smith.

The refuse of hematite or "slack," has also been sponged and balled, yielding 34 per cent. An ore containing 6 per cent of titanium, has been balled and will no doubt hammer well.

These trials indicate that all kinds of ore can be well worked by the Pomeroy processes. Also that ores too sulphurous or refractory to be worked in the blast furnace can now be utilized. The process also saves at least one ton of coal in making a ton of blooms from the ore, compared to the blast and puddling process for blooms. Pea coal, or fine bituminous, answers for sponging.

The Utilization of Waste Gases from Blast Furnaces.—The blast furnace proprietors who have adopted one or other of the different methods employed for bringing down the gases report satisfactorily of the result. This with regard to one plant of furnaces is seen in the circumstance that between 250 tons and 300 tons of fresh drawn slack heretofore required in raising the steam for their blowing engines and for heating the blast is now being offered for sale. The concern is that of the Parkfield Iron Company at Wolverhampton. If the practice should be extended throughout the whole of the district, and the proportionate saving equal to that here stated, a large amount of economy will have resulted; for notwithstanding that in some cases the adaptation even of the least expensive method is regarded as costly, still the ultimate saving is very marked. Speaking of this one case in particular, the saving may be put as equal to the developing of 500-horse power out of nothing!

Iron and Steel—A New Blast Heating Apparatus.—Homer Hamilton, Esq., of Cleveland, has invented a new blast heating apparatus which, if it performs all that is claimed for it, will prove valuable to furnace owners. The apparatus consists, first, of eight or ten large pipes, divided by means of a horizontal or inclined partition into two chambers, of which the upper one opens at one end and the lower at another. Upou each of these base pipes are eight upright pipes, opening into the upper chamber of the base pipe, and closed at the top. Inside of each of the upright pipes is a smaller tube, opening at one end into the lower chamber of the base pipe, and at the other into a chamber at the upper part of the outer upright pipes. The object of the invention is to construct a simple and effective device for heating the air that is carried into a blast furnace, and consists in the above arrangements of pipes, so that the air will be exposed in thin sheets to heated surfaces, and expansion and contraction will not injure the apparatus. Its operation will be as follows: The burning gases will surround the upright and base pipes, and will heat their surfaces. The air is forced into the lower compartment of the base pipes, thence it passes up into the inner tubes to the upper part of the upright pipes, which are rounded, enlarged and depressed in the center for the purpose of facilitating the transmission of air from the inner tubes to the outside upright pipes, and to avoid friction. The air then passes down the upright pipe outside the inner tube, exposed in a thin sheet to the heated pipe, and is thence transmitted to the upper compartment of the base pipe. It then goes into the blast furnace, or to another heating apparatus of similar construction. It must be understood that for a blast furnace of usual size a series of eight or ten base pipes with their upright and inner tubes, should be provided in order to have a sufficient heating surface. The pipes all support themselves, and cannot strain any supporting frame or other machinery. For that reason a much greater degree of heat can be obtained—a very desirable thing in blast furnace economy. The points of the invention are: First. The arrangement of base pipes and uprights so that the air to be heated will pass from one compartment of the base pipe through all the verticals into the other compartment. Second. The rounded enlargement on the upper end of each upright pipe to prevent friction of the air. Third. The construction of the apparatus so that the air is exposed to the heated surface of the outer upright pipe in thin sheets, and is therefore uniformly heated.—*Pittsburgh Commercial, Aug.* 7.

Special Method of Blooming.—We have lately examined a modification of the Catalan process in the old form of the forge-hearth, at the Logan Ironworks, Bellefonte, which is extremely simple and direct, resulting in the forming of, commercially speaking, an almost absolutely pure iron. The furnace is a few inches above the general floor of the forge-house, and the size about large enough to make one bloom of 200 or 225 lbs. It is about three by four feet, the long way running back from the workman. The instrument for turning, lifting, and aggregating the iron is called a "furgeon," and answers to the rabble of the ordinary puddling furnace. The waste heat passes up and through a chamber immediately over the forge-hearth, where the pigs are placed which become red hot before they are ready to be drawn down upon the bed of charcoal previously prepared. The pigs thus drawn down upon the charcoal bed are covered and the blast turned on into both tuyeres right and left. After a few minutes the iron begins to melt; it is decarbonized by the blast, is worked into shape by the furgeon, and then lifted up clear of the bed and laid upou the top of the same bed again, some additional charcoal put around, and the blast turned on. The iron now is melted in what is called the sinking process, wherein the iron drops through the coal into the hearth until entirely passed into the hearth; there it is again agglomerated into the ball, or "loup," by the furgeon (pronounced *furgun*), the blast having previously been turned on fully; it is then lifted out a balled loup and carried to the hammer. The cinder is tapped off through a hole in the front iron plate, and is rich in iron, with so much silex that it easily emits sparks when the penknife blade is struck against it. Of course, this process is attended by a large loss of iron, while the loup, which gives rise to the cinder, is not thereby improved, as in the puddling furnace. But in this particular instance the iron is singularly pure, and the blooms command $85 per ton at the forge. One ton and a half of pig yields 2,464 pounds of bloom. The charcoal furnace yielding the iron is nearly adjoining the bloomary.

This furnace is only 32 feet high, about 26 inches across the tunnel-head opening, 8½ feet bosh, and the slag is allowed to flow out from the hearth whenever it rises above the fore hearth. The breast is covered with a simple plate of iron; the cinder is always in sight; as soon as the iron appears, the crucible, or tapping-hole, is opened and the iron is tapped off into iron moulds. There are three casts per twenty-four hours, two tons per cast; 150 bushels hard coal (18 pounds to the bushel) to the ton made. Charges, 700 to 750 pipes ore (brown hematite), 27 bushels charcoal, 80 pounds gray limestone of good quality; pressure, a half to three-quarters of a pound per inch; nozzle, two and a half; two woodeu blowing cylinders worked by water-wheel. Some finery cinders, about thirty to forty pounds, are added to the charges and said to improve the iron, which at present, May 26th, 1869, is all forge iron, and used at Stewart & Co.'s wire factory, and reported as a very fine iron.

This bloomary process is interesting as an example of blooming from pig iron, and is the same process spoken of in a certain United States report, if we mistake not, as not existing in this country.—*American Exchange and Review.*

Increasing Exportations of Iron and Steel from England.—It has been shown says the "Engineer" that, notwithstanding all the outcry which has been raised of late years as to foreign competition, the exports of iron and steel from the United Kingdom attained a larger total in 1868 than in any former year. The quantity and value of the exports since 1859 is as follows:

	Tons.	Value.
1859	1,465,191	12,314,437
1860	1,442,045	12,154,997
1861	1,322,649	10,326,646
1862	1,501,451	11,365,150
1863	1,640,949	13,150,936
1864	1,502,964	13,310,848
1865	1,617,509	13,471,359
1866	1,683,390	14,842,417
1867	1,882,650	15,050,391
1868	1,945,246	15,021,907

Malleable Cast Iron.—For the production of this material most of the German founders use first fusion pig, free from sulphur and phosphorus, or Scotch pig. Styria also furnishes a suitable iron which can be used only in the north of Germany, however, on account of the expense of transportation and high duties. On account of the competition of wrought iron, great cheapness is very essential to its sale. The makers keep secret the brand of iron which they employ, but it is well understood that the brands are not the same in different establishments. The iron is melted in plumbago crucibles, holding about 30 kilog. They are covered with porcelain lids, to keep out impurities and cinders which reduce the high heat requisite for the process. The fire in which the crucibles are placed is from 630 m. to 940 m. square, and is surrounded with bricks of porcelain earth. The use of blast is not advantageous, since the economy of time is offset by a greater consumption of coke. The natural draught of the chimney is sufficient when the furnace is properly constructed. An essential condition of success is a high heat at the moment of pouring. Practice enables the caster to estimate the heat of the furnace, and he recognizes the precise moment by plunging a bar of red hot iron into the crucible, from which, upon being withdrawn, the metal flies off in sparks. The crucibles are raised with tongs with curved jaws, and the pouring is done with all possible speed—the surface being first cleaned. By cementation the casting acquires the properties of wrought iron, having some analogy to steel. The operation consists in subjecting the castings to a prolonged red heat in a bath of pulverized red hematite. They are arranged in boxes of cast iron called muffles. These are square, and with air-tight covers. In arranging the castings in the boxes they are placed in layers alternately with layers of hematite. The cementing furnace is very simple. The grate is in front, and the draught of the chimney carries the hot air around the boxes. The heat should be conducted with care, starting rather vigorously, in order to reach the desired temperature quickly; then supplying the furnace at regular intervals. The cementation lasts three, four, and five days, according to the size of the pieces. A charge is about 350 to 450 kilog. of castings. In arranging the charges large pieces should not be mingled with small, and those muffles containing the larger pieces should be placed in the furnace first. On the other hand, the smaller objects are placed on the sole of the furnace. Without these precautions many pieces may be burned, or badly decarburized—the latter becoming something intermediate between iron and steel. When the operation is deemed complete the fire is allowed to fall, but the furnace is not uncharged until it has gradually cooled. Practice plays an important part in the management of the firing, as the temperature can be judged of only after prolonged experience.—*La Génie Industrielle.*

Improvement in Rolling Iron.—A new description of roller, to be employed in the manufacture of iron plates, bars, tubes, &c., has just been invented by a roll turner, named Robert Robertson, who is at present employed in the Coatbridge Iron Works, the property of Messrs. Martin & Son. The invention, if it succeeds as well as it at present promises to do, bids fair to completely revolutionize the system of rolling, as the new machine possesses so many advantages over the one at present employed. The invention consists of having the rolls tubular, instead of solid as at present, with a stream of water introduced inside of the rolls. The advantages are said to be that the new rolls are from 7 to 8 cwts. per ton lighter than those in use at present, while the water inside the rolls prevents the heated iron from due expansion, while undergoing the process of rolling, and saves a great amount of drag upon the engine. The saving in this respect will be better understood when it is stated that in the item of brass bearing alone the amount of mean steam saved by the new invention is at least 15 per cent. No steam arises from the rolls while working, so that the workmen can pursue their avocations with greater ease and facility. No scales stick to the rolls, consequently the finished bar or plate presents a finer surface. The new roller will also last much longer than the solid rolls, while the chances of sudden breakage are reduced to a minimum.—*North of England Coal and Iron Trades Review.*

Siemens' Open Hearth Furnace.—Mr. Siemens informs us that the cost of the production of steel made in his open hearth furnaces, depends upon the cost of the materials, pig-iron, scrap and the cost of the labor. The following, however, is the cost of production in England, viz: for a charge of *four tons, three* such charges being made in 24 hours in each furnace.

10 cwt. pig-iron.
3 tons 10 " scrap steel.
8 " spiegeleisen.
2 tons ...... coal.

Labor—five men (melter, assistant melter and three laborers.) Repairs, interest, management and royalty. This made the actual cost of the steel ingots £5 10s. per ton.

The cost of one of these furnaces here, with gas producers and all equipments, such as ladle, tramway, etc., would be about $14,000.

As to the durability of the furnace, the best evidence is contained in a letter from Mr. Siemens, dated February 16, 1869. He writes, "you will be interested to learn that the manager of the Bolton Steel and Iron Works (Mr. Webb), has told me that his furnace crown (open hearth steel melting) has stood 70 charges, and looks as good as new. At the lowest computation the furnace will last 100 charges, and the cost of repairs will amount to less than *one shilling* per ton of steel melted."

We quote again from a late letter of Mr. Siemens—"These furnaces are now in regular operation at Swansea, Bolton and Crewe, where first class steel is made by them; that made at Bolton having been tested by P. W. Barlow, Esq., F. R. S., on behalf of the Institute of Civil Engineers, who are desirous of establishing 'standards for the employment of steel in construction,' was found superior in tenacity and ductability even to crucible steel, and far superior to Bessemer steel."

We copied a paragraph which appeared in "Engineering" in reference to Mr. Samuelson of Middlesboro', England. We learn from an authentic source that it is quite true. Mr. Samuelson has ceased to manufacture steel according to the "Siemens-Martin" process, but his failure must not been held to affect the process, as he did not work according to Mr. Siemens instructions, but allowed himself to be guided by M. Martin, who was unacquainted with English irons, and he also followed his own notions. Moreover he had no chemist and consequently was working in the dark.

CLEVELAND IRON MAKING.—It seems but a short time since, and it is in reality less than three years, when the furnaces in the Cleveland district were making about one million tons of pigs yearly. Notwithstanding the depression in trade they are now reported to be turning out iron at the rate of 1,400,000 tons yearly, or nearly one-third of the whole pig-cast of England, Scotland, and Wales. The Cleveland ironstone is cheaply got, but it is lean and highly charged with phosphorus. Coke, on the other hand, is dear, and is likely to become dearer. But by the employment of the most complete mechanical appliances the cost of production has been brought to a very low figure. Had the Middlesboro' ironmasters access to the vast quantities of slack from the Durham and Tyneside pits, they would soon turn out a cheap coke by washing, but there would still be the long carriage by rail. The ironstone is calcined in kilns, but as it is not of the carbonaceous variety—that known as "black-band"—there is no opportunity of effecting the saving which, with that variety, is obtained by coking in close kilns, upon Mr. Aitken's plan, so successfully employed near Falkirk. Even 22 cwt. of the best coke to a ton of pigs seems a large quantity when the heat really absorbed in decomposition, liquefaction, and in raising the temperature of the air is considered. A good cupola in regular work will melt, of some kinds of iron, as much as sixteen times the weight of coke used. Yet cupolas vary greatly, and some, from various sources of loss, will not do half as well as this. And blast furnaces vary greatly also, some using, with the same materials, one-half more fuel than others. Yet it is difficult to see the way to any decided improvement in blast furnaces from which the gas passes off at a temperature hardly above 500 degrees, all the gas being saved and burned under the boilers and in the heating stoves so as to require no other fuel whatever.

The Cleveland forgemasters know how to make a good soft iron, hardly cold short, from their highly-phosphuretted pigs, which, in the ordinary course of things would work into cold short bars. The whole secret, if it be a secret, is in a liberal fettling with rich magnetic oxide of iron, of which large quantities are now purposely imported from Sweden. Mr. Gjers has made some very interesting analyses of the cinder, which was highly charged with phosphoric acid, while the puddled bar was of good, mild quality.

Puddling costs dearly in Cleveland. It is not long since it was 10s. 6d. per ton, but it is perhaps somewhat less now. It seems to be settled that none of the "mechanical puddlers" will ever answer, although Mr. Tooth managed to make some very fair blooms, eight years ago, in his revolving puddling churn. But why, after Mr. Bessemer's patent expires in February next, cannot it be adapted to some extent to puddling, so as to drive off not only the silicon, but a good portion of the carbon by air alone, leaving the puddler half an hour's work or less to be done by hand. A great deal was said, some year or two ago, about the so-called "Richardson process," which was merely injecting air under the surface of the iron in a puddling furnace by means of a tubular rabble. The injection of air in such a manner must have been very ineffective for two or three reasons, and although the treatment could not possibly do harm, it is difficult to see how it could, by being continued for but a few minutes, do any considerable good. Yet much was claimed for it at the time, although nothing is heard of it now. But why should not some modification of the Bessemer converter, on a small scale, and arranged to work into, say, half a dozen or more puddling furnaces, be arranged to bring the iron to the point where only the puddler could finish it? In this case, too, all the iron would be melted in a cupola, which would be cheaper than melting it in the puddling furnace. A large saving of labor and a considerable saving of coal might, it would seem, be thus affected. At any rate, the experiment should be carefully tried.

It would be interesting to know whether the so-called "Radcliffe process," of knocking five or six ordinary blooms into one before shingling, is still being practiced with success. It seems extraordinary that such a "process" should be the subject of a patent, although it may be more extraordinary that any forge master should adopt a "process" so likely to shut in cinder with the iron. The published tests of the iron made by this "process" showed an elongation, in breaking, of but about 5 per cent, which is very little, and indicates harshness and brittleness. By mistaking a column of figures in Mr. Kirkaldy's report, the "Engineer" reported the elongation as 30 per cent.

It would be interesting also to know whether Mr. Bramwell's suggestion, that all bar iron should be rolled in a hoop, can be successfully carried out. There are difficulties in the way of bringing together the two ends of a pile and welding them preparatory to hanging the ring upon an overhung roll, and the necessity for some means of shifting the roll into and out of the outer housing would create an additional difficulty. But, supposing all this once done, and that the hoop could be successively shifted from one grove to another, the bar or hoop would be rolled out with a continuous motion, without, "passing," and without any crop ends. It would be better afterwards to find the weld and cut the hoop there, when it would drop out a straight, clean cut bar.—*Engineering.*

MANUFACTURE OF NAIL-PLATES.—Hitherto much trouble has been experienced in finishing the wrought-iron plates from which cut-nails are made, the trouble arising from the adhesion of "scales" to the finishing rolls. This, by destroying the uniformity of the surfaces of the rolls, caused them to work unevenly and imperfectly, and consequently impaired the smoothness of the plates. A Pennsylvanian inventor has recently invented and put in operation a simple contrivance by which the rolls are automatically kept clean, thereby preventing all hindrance to their perfect operation and insuring the uniform smoothness of the plates. It consists in small friction-rollers so applied in relation with the rolls as to sweep the scales therefrom as fast as formed; the rolls being thus kept constantly bright. By this means, not only is avoided all the trouble of cleaning the rolls hitherto necessary, but the nail-plates are made much better. It is probable that the principle of the device will be applied with profit to the rolls of other machinery for shaping iron while hot.—*American Artizan.*

FORTY-TWO TON HAMMER.—In England a huge steam hammer, weighing 1,000 tons, is being made for the Russian Government. The hammer head weighs 42 tons, the anvil block 500 tons, and it is to be used in forging steel guns.

STEEL AT ANY PRICE.—The amiable journalists who, until the advent of "gunpowder steel," condemned all steel, are deriving consolation from the utterances of Sir William Armstrong, at the Newcastle meeting of the Mechanical Engineers. This gunpowder steel, invented by one Heaton, was, however, an exception to everything else. No words and no superficial measurement of type were sufficient to explore its virtues. It is explicable that Sir William has not visited the deserted "shanty" known as Langley Mill, and from the koran to be found there, developed his knowledge of steel. We are told that he was once one of the "steel at any price" party. So far from this, he has been a most uncompromising enemy of steel in all forms. He stood out, for a long time, and in spite of every recognizable fact, against steel inner tubes for his guns, without which they might almost as well have been constructed of leather. Indeed, there is no such thing now as an "Armstrong gun." The gun is Fraser's and Fraser's only, and he has not yet received the half of what he deserves for kicking aside the Armstrong delusion. Just as engineers complete their education they learn the value of steel, and it is merely a pity that the tergiversating journalists of whom we speak are not yet out of the woods in their wild goose search after evidences of its value.—*Engineering.*

THE PITTSBURGH STEEL WORKS.—The "Black Diamond" Steel Works of Park, Brothers & Co., are the largest in the city, covering five acres, and comprising a steel forge, rolling mill, converting building, melting houses, etc. Here are 17 steam hammers, 5 helve hammers, 7 steam engines, 4 trains of rod and bar rolls. The capacity of the works is 20 tons of cast steel and 10 of common steel, daily, the number of men employed, 240. This concern manufactures cast steel boiler plate for locomotive engines, tool steel, machinery steel, burglar proof safes steel, plough, and other agricultural steel. The buildings and machinery of the establishments are all first-class, and kept in the nicest possible order. This is a sample of the very best class of establishments in Pittsburgh.

The establishment of Messrs. Hussey, Wells & Co., one of the largest steel works in the city, has a capital of $1,000,000, runs 144 furnaces, and makes about 30 tons of steel per day. They employ about 200 men, and sell as fast as they can manufacture, which is the best point that can be made with regard to the steel-workers of Pittsburgh.—*Exchange.*

STEEL-HEADED RAILS.—Steel-headed rails are made at the Trenton (N. J.) Rolling Mills by the following process: The steel which is to form the head of the rail is first wedded to a quite thin piece of iron. The combined bar is then beaten and rolled down until the iron is very thin and the steel reduced to about half its former bulk. After this operation is completed, the whole quantity of iron requisite to complete the bulk of the rail is added to the bottom of the combined bar, and welded to the thin layer of iron. This process, it is asserted, doubles the strength of the weld between the iron and the steel, always a difficult operation to perform. The old process consists in welding the relative thickness of iron and steel at one operation, but the new method is reported to furnish better rails.—*U. S. Railroad and Mining Register.*

REDUCING ALUMINIUM FROM ITS ORES.—Mr. A. L. Fleury, of Boston, U. S., mixes pure alumina with gas tar, resin, petroleum, or some such substance, making it into a stiff paste, which is divided into pellets, which are dried in an oven, then placed in a strong retort or tube, which is lined with a coating of plumbago. They are then exposed to a cherry-red heat. The retort must be sufficiently strong to stand a pressure of from 25 to 30 lbs. on the square in., and be so arranged that, by means of a safety valve or tube, the necessary amount of some carburetted hydrogen gas can be introduced into the retort among the heated mixture, and the pressure of from 20 to 30 lbs. on the square in. be maintained. The gas alluded to is forced into the retort by means of a force pump. By this process the alumina is reduced and the aluminium remains as a spongy mass, mixed with carbon. This mixture is re-melted with metallic zinc, and when the aluminium has collected in a metallic state, the zinc is driven off by heat. The reduction is due to the carburetted hydrogen gas under pressure. The time required for reducing one hundred pounds of alumina earth, cryolite, or other compound of alumina, should not be more than four hours; when the gas can be applied in a previously heated as well as strongly compressed state, the reduction takes place in a still shorter period.—*Chemical News.*

RUSSIAN RAILS.—A great festival has lately been held at the Poutilof rail factory (St. Petersburg) on the occasion of the completion of 2,000,000 pounds (about 800,000 cwt.) of rails. The rise of this factory is mainly owing to the privileges granted by the Russian Government to companies purchasing their railway material in Russia, and to large orders for the governmental lines. Hitherto it might be reckoned that a considerable part of investments of English capitalists in Russian railway shares might come back in the shape of payment for rails and rolling stock. Now we see that, as regards rails, this hope must be given up; and the same thing would probably have taken place in respect of carriages, had not the new Struve's extensive carriage factory (near Moscow) been recently burnt down. Of locomotives and carriages we may further observe that Russian companies have always preferred the cheaper French and German supplies. The Poutilof rails are stated by Russian engineers to be heavier, and nearly twice as dear as the foreign, but more durable.—*The Engineer.*

BESSEMER'S LATEST PATENT.—Henry Bessemer, whose name has been long identified with improvements in the manufacture of iron, has recently taken out a patent in England on a new process, the object of which is to secure a more rapid and less expensive mode of fusing malleable iron and steel of different kinds, and to obtain cast-steel and homogeneous malleable iron therefrom. In order to accomplish this, the inventor avails himself of the property of gaseous fluids to rise in temperature in proportion as they are compressed, and he constructs furnaces of sufficient strength to withstand an internal pressure equal to two or more atmospheres, and retains in such furnaces the products of combustion under such an excess of pressure over that of the external air as will produce the high temperature necessary for rapidly fusing malleable iron and steel of any kind or quality.

RAILWAY NOTES.

Trial of a New Kind of Railway in France. —A commission was appointed to study and report upon a system of railway of which a specimen had been laid down by Mr. Geoffroy, of Rouanne, by the side of the road from Poilly to Charlieu, in the Loire. The principle of this railway, which is intended for local lines, is that the rails are laid on the natural profile of the ground, with the addition of a central rail, upon which work horizontal wheels wherever the curves or gradients are at all sharp—in fact a modification of Mr. Fell's arrangement. The report of the commission is not published, but the following are the conclusions of the reporting engineer: (1.) The system of railways presented by Mr. Geoffroy allows of trains being worked with perfect security on inclines of 0.06. (2.) The arrangement of the railway in those parts where the central rail is introduced seems to resolve the problem as simply and economically as possible. (3.) The breaking off of the central rail in those parts where the incline does not exceed 0.025 causes no inconvenience, adhesion of the vertical wheels being then sufficient; and the horizontal wheels take on and leave the central rail without any shock that can do injury to the machinery. (4.) The action of the brakes of the engine is sufficient to stop a train of twenty-two tons within 80 feet on the inclines of the experimental line. (5.) The engine and carriages pass without difficulty, and without the aid of the central rail, at the rate of twelve or thirteen miles round curves of 260 feet radius. (6.) The passage of the train by the side of the ordinary road did not appear to frighten horses very much; and in any case this inconvenience cannot be very great, on account of the ease with which the engine can be stopped. The effect will also be greatly diminished by the erection of a barrier that must be placed between the railway and the high road." We are sorry to say that the opinion contained in the last paragraph is entirely opposed to that of the engineers and others of Paris and Nantes with respect to the road locomotives and steam rollers, and the latter are not now allowed to be used in the day time, except the street be blocked, on account of the accidents that happened. Still, if costly works can be avoided by the use of a central rail, we may have local railways at a comparatively small expense elsewhere than by the side of high roads, and there is no reason whatever, except the objection of level crossings, why such simple railways should not be adopted. It is the opinion of the commission that there would be a saving of expense in the case of such a railway as compared with ordinary lines of 40 per cent, and that therefore it would be well to adopt the arrangement where the difficulties of the ground would render the construction of an ordinary railway too costly. —*The Engineer.*

The Patent Shaft and Axle Co.'s Works and Products.—This company, says the correspondent of "The Engineer," employ at their two establishments—the Brunswick and the Old Park Works—from 4,000 to 5,000 hands, and that the department I visited occupies 400 workpeople, and turns out weekly over 300 pairs of wheels. My attention was first directed to the manufacture of some solid wrought-iron wheels with Kirtley's spokes fitted with best "double star" puddled steel tires, or tires of solid cast-steel, secured either with Mansell's retaining rings or ordinary bolt and rivet fastenings. Kirtley's spokes are rolled from B B iron in ordinary rolling mills, they are then bent into a triangular shape, so that when eight are placed together they form a complete circle, technically called a "skeleton." The machine in which they are shaped is called a spoke-bending machine. This apparatus has a bed similar to a planing machine, the "saddle" of which is worked to and fro by a cranked motion. The saddle has fixed upon it a center block, and two side blocks or arms. The center block, which forms the crown of the spoke, is moved horizontally by eccentric motion. The side blocks are then simultaneously brought together by a single movement of the machine, embracing the sides or legs of the spoke. After being thus shaped, another movement lifts up the spoke from the die, when it is ready for bossing; that is, the spokes, arranged in a circle or skeleton, are placed on a smith's fire, and the center part is heated to a welding heat, and a large washer formed by a steam hammer, also heated, is welded on to the center of the spokes by ordinary smiths' sledges. The spokes being sloped at the corners of the crown, leave when put together interstices in the shape of the letter V, which are filled up by what are called "V-pieces. The wheel is then ready to receive the tire. The accuracy of the former is, however, first secured either by ordinary lathe-turning, or perhaps (more frequently) by an ingenious apparatus expressively called a "squeezing machine." This machine consists of a circular bed-plate, on which is worked eight slides, which are worked simultaneously to one center, forming a perfect circle. The machine is capable of exercising a pressure of 1,500 tons after making due allowance for all friction. The tires, which are rolled, bent and welded, are also tested in what is called a "blocking machine," an operation which fully proves the soundness of the weld. The tire being expanded by heat is next shrunk on to the skeleton by immersion in cold water, and the wheel is then ready for the finishing touches, such as boring and grooving, to receive the key of the axle. The wheel and the axle are joined together by pressure under gauge by hydraulic power, being further secured by steel keys. The wheels in pairs are turned in wheel lathes to accurate dimensions, and to road gauge, after which they are dressed off and painted. The wheels vary in size from 18 in. diameter, for lorries, to 6 ft. diameter for engines.

American Locomotive Repairs.—From a number of reports of some of the leading American lines of railway, we have compiled, says "Engineering," the following statement of the average annual mileage of their engines, and the cost per mile for repairs. As a general rule, only train miles are reckoned by American railway managers, although in some of the following cases engine miles are reckoned in dividing for the cost of repairs per mile.

The cost of repairs, given in pence per mile, is in a depreciated currency, the cost in silver being about three-fourths that in paper. Allowance must, of course, also be made for the very high price of labor, and all materials, except wood, in the States.

The Reading, and the Baltimore and Ohio Railroads are very largely engaged in the coal traffic, the latter line having 239 goods engines out of a total of 290 of all kinds.

NAME OF LINE.	Year.	Number of Engines.	Total Mileage.	Average Mileage for each Engine.	Cost of Repairs in *Pence* per Mile.
					d.
Pennsylvania	1868	431	8,693,328	20,031	6.04
Erie..........	1866	371	7,109,139	19,162	7.44
Baltimore and Ohio........	"	290	5,564,036	19,186	6.75
Grand Trunk (Canada)....	½ 68	298	3,270,743	21,951*	3.54
Reading..................	1868	269	4,500,135	16,730	6.44
Chicago & North-Western,	1867	248	....	25,000(?)	5 00
Illinois Central...........	1868	169	4,593,446	27,180	6.36
Boston and Albany........	"	144	2,727,558	18,941	6.43
Chicago and Quincy.......	1867	122	2,648,554	21,709	6.54
Michigan Southern	1868	101	2,667,191	26,408	4 38
Michigan Central..........	"	98	2,055,049	20,969	6 27
Mobile and Ohio...........	"	94	1,167,204	12,417	14 34
Cleveland and Cincinnati..	"	83	2,177,407	26,234	4.61
Cleveland and Pittsburgh..	"	73	1,616,216	22,140	3.86
Louisville Nashville.	"	66	923,471	14,000	4.72
Morris and Essex.........	"	57	922,847	16,295	4.23
Boston and Maine.........	"	43	892,661	20,783	4.50

PERILS OF INDIAN RAILWAY TRAVELING.—A late number of the "Cornhill," gives the following interesting facts :—The only accidents peculiar to India are those which are the result of floods, cyclones, and such disturbances of the elements. In 1864, the lower part of Bengal was visited by a tremendous hurricane, but although sheds were leveled to the ground, roofs were torn away, and part of a train, including the engine, was blown over, no lives were lost. On this occasion damage to the extent of £50,000 was done to railway property. On another occasion, on the Bombay side, the results were even more disastrous. A viaduct on the Great Indian Peninsula Railway was carried away by the violence of a flood, and a night train following soon after ran into the vortex, taking with it a number of native passengers, fourteen of whom were killed. The bridge over the Nerbudda River, on the line between Bombay and Baroda, has more than once suffered injury from the violence of the torrent. In Scinde, on one occasion, a whole village on the banks of a nullah was carried away, and brought down a railway bridge in its ruin. Wild animals have also occasionally been the cause of accidents. The other day an elephant charged a train and was killed, but such was the resistance which he offered that the engine-driver was thrown off and injured. A buffalo has also been known to throw a train off the line by getting in its way. In spite, however, of these special causes, railway traveling is as safe in India as in England. Last year the number of fatal accidents was one and a half per million. There are perhaps more frequent cases of death from natural causes in Indian Railway trains than elsewhere, and the ominous heading "found dead" may be seen on the returns of casualties. The fact appears to be that many natives commence a journey *in extremis*, in the hope of reaching some sanctified spot where to die, and the vital spark expires before the poor creature can reach his destination.

FAST RUNNING.—The speed of the New York and Chicago Express, over the New York Central Railroad, has been as high as 51.7 miles per hour for 81 miles, between Syracuse and Rochester.

*Equivalent average for whole year.

PEAT FOR LOCOMOTIVE FUEL.—The State Line Bavarian Railway has been worked with turf since 1847, or for above 20 years, rather from necessity than choice. The peat is got from the bogs of Haspelmoos. The method of its preparation is that of M. Exeter, whose statement is that he can produce 10,000 cubic meters of prepared turf per annum at a cost of 2.80 francs per meter. The turf, as dug or dredged, appears loaded with much admixed earthy matter; from this it is separated by grinding up, large dilution with water, and decantation of the water bearing the light peat particles still in suspension from the heavier earthy matter which has deposited. This is let to dry in layers exposed to the air like "hand turf," and then compressed in molds by power. From other sources of information on the subject of artificially prepared peat, we conclude that these results admit of being contested. As a locomotive fuel, turf, at the best, is a bad and troublesome one; it gives much smoke and sparks, leaves an evil smell after it, experienced in the train, and is so bulky as often to need supplementary wagons to feed the tender on a long run. There is also great waste by the broken particles passing through the fire-bars.

As to comparative heating powers (not theoretic, but taking into account all these circumstances), the result of nine years' working on the Bavarian State Line indicate that 100 cubic feet or 2.486 cubic meters of the prepared turf of average quality and dryness, are equivalent to 312.5 kilograms of coke, or to 3.135 cubic meters of white firewood, *i. e.*, of wood principally of birch, beech and alder. Thus during this interval of working, the cost of firing with turf was about half that of coke (*in Bavaria*), and two-thirds that of wood. But taking everything into account, as derived from the accounts of the line for 1861-62, it may be shown that even this is too favorable, for that the fuel account per kilometer per engine stands thus:—

	Fired with Coal.	Fired with Peat.
Passenger Engines.	0 166f.	0.172f.
Luggage Engines..	0.249f.	0.207f.

It is thus, though rather cheaper than coal for slow traffic, a trifle dearer than coal for fast, and that even in Bavaria, where coal was then exceptionally dear.—*Practical Mechanics' Journal.*

RAILWAY IMPROVEMENT IN NEW YORK CITY.—The Legislature of the State of New York, at its last session, authorized the construction of a railway station on the Fourth avenue, to be used jointly by all trains arriving in this city from the north.—This station will extend from Forty-second to Forty-fifth street, closing Forty-third and Forty-fourth streets, and will occupy an area of about 800 feet in length by 300 feet in width, taking in for this purpose 150 feet on either side of the avenue. The Hudson river road is to be connected with the Harlem and New Haven track, and all the trains of these three roads are to be brought under one roof. The estimated cost of this improvement will amount to $1,000,000, and it is stated that the permanent way of these lines are to be so combined as to permit the freight carried over them to be all delivered at the large depot now occupying what used to be St. John's Park. The advantages which these arrangements will afford to travelers and the commercial community over the present disjointed state of city and country intercommunication, are apparent. —*Scientific American.*

Steel Rails.—Probably nothing is better established in railway practice than the superior economy of steel tyres, as compared with iron, even at twice the original cost per hundred weight. The wear of rails is less rapid than that of tyres, except where the traffic is incessant and enormous. Hence, probably, arises the nice calculation—never applied in the case of tyres—of interest and compound interest, as accruing upon iron and steel rails respectively.

It is now being industriously represented that the royalty on Bessemer steel rails is £2 per ton, and that this royalty will cease, with the expiry of the patent, in February next. The royalty is, and has all along been, £1 per ton only, and of this but 17s. 6d. will cease to be levied in February next.—Steel rails have hitherto been put down mainly on those portions of railways on which the traffic was unusually heavy, and as these portions have, for the most part, been already laid in steel, the necessity for the further use of steel may appear less urgent now than it did a few years ago; but it is none the less urgent where iron rails, in exposed situations, must now or soon be renewed. Rails that can be safely permitted to wear another year, ought, of course, upon every consideration of economy, to be left to fulfill their full service; but there are thousands of tons of iron rails, on our great lines of railway, which will have completely worn out this year and which must, therefore, be renewed before winter sets in. And as it is easy to prove that, under heavy traffic, the wearing value of steel, even at £12 per ton, is very much more, after allowing for the difference of cost, than £1 per ton greater than that of iron rails at £6 or £7, it would be anything but economy to put down iron rails again to last two, three or four years, merely to escape a moderate present royalty, and to take advantage of its diminished amount in 1871, '2 or '3. So far as extensive observations go, the wear of steel is from ten to twenty times that of iron, while as for breakages, the fractures of steel rails do not exceed one per cent of those of iron rails. In situations, then, where iron rails are not likely to wear longer than a year or two, it would manifestly be unwise policy to replace them with iron merely to avoid a few shillings extra royalty on steel. This point is, we think, too well understood to require any lengthened argument, and it is not, therefore, to be wondered at, that within so short a time of the expiry of the Bessemer patent, the steel rail mills continue, according to the current trade reports, to be very well employed.—*Engineering*.

The Reading Railway Shops.—This company has the largest shops, foundries, and rolling mills in the city of Reading, and gives employment to over 2,000 men. The company makes its own locomotives, cars, and all other work necessary to equip and keep the road in running order. Two locomotives are made per month, but the demand for engines is so great that a contract has been made for twelve at the Baldwin Locomotive Works in Philadelphia. In the rolling mills sixty tons of rails are made each day, and in the two foundries 12,000,000 lbs. of castings per annum. The brass foundry yields 200,000 pounds of castings per year, and 1,000 tons of wrought iron are also made during the same period. The pay of the workmen in all the shops of the company amounts to about $85,000 per month.—*American Railway Times*.

Fairlie's Steam Carriage.—The "cabbage garden" at Hatcham is likely to become as famous as the race course at Rainhill, only that there is no *race*, so dear to the heart of every Englishman, except a race against time. Mr. Fairlie has a combined engine and carriage, weighing but $13\frac{1}{2}$ tons empty, and capable of seating 66 persons, which is whisked around the Hatcham cabbage garden—upon a villanous permanent way, not exactly a circle, one-ninth of a mile in circumference, and having three quadrants of 50 feet radius. Seeing *is* believing, and we only regret that there is no Act of Parliament to compel every railway director and every railway Mephistopheles (the locomotive superintendent) to go to Hatcham and see. Thirty miles an hour and more has been accomplished, but we considered twenty-five preferable, and we stipulated for this, and no higher, speed when we sat foot upon the engine bogie. With the Field boiler there was no end of steam—160 lbs. per square inch—and the regulator could hardly be touched by the skillful hands of Mr. Clemenson without giving a jump to the whole affair almost enough to send us into centrifugal convulsions. The gentleman who, after first addressing the Institution of Civil Engineers, declared that the "theater" made 60 revolutions per minute during the whole period of his communication, would have been as much astonished at the circular movements of the little edition of a railway train at Hatcham. Round and around, four times round the cabbage garden, up and down gradient, and almost half a mile, was repeatedly done in one minute.

The merits of this system will not long want appreciation. Even the Ramsbottoms, the Armstrongs, the Stirlings, the Beatties, the Kirtleys, the Cudworths, the Cravens, the Johnsons, the Martleys, the Pearsons, the Connors, the Fletchers, must at last give in. The motion is more like sailing than riding, that is, the motion in the carriages. The "centrifugal convulsions" to which we have referred were generated only upon the engine bogie, and in the next carriage, this being the first of a certain number *in futuro*, the engine will be so connected with the carriage as to prevent any jerking or striking, at full speed, a curve of even three-quarters of a chain radius.

It is but just to Messrs. Brown, Marshalls & Co., to mention that the "train"—all in a single carriage—is the model of comfort and neatness. When we first saw the carriage, in the makers' factory at Birmingham, under a low roof, we took the impression that the compartments were cramped in the matter of space. But in the open air of the Hatcham cabbage garden we found, not alone by the sensation of comfort, but still more so by the act of measurement, that the seats were at least as capacious, and that for thick men, as any known near the Metropolis.

The railway company which first secures the exclusive use of Fairlie's steam carriage has dividends as good as declared for its shareholders.—But with one carriage there will be many, and let us hope that all the companies may, by these means, come round to dividend payments at last.—*Engineering*.

The Manchester, N. H., Locomotive Works have been very much enlarged, and six locomotives are turned out monthly. The works employ 400 men.

PACIFIC RAILROAD TIME TABLE.—The following statement of Time and distances is given by the *Western Railroad Gazette:*

	Miles.	Hours.
New York to Chicago, Ill.	911	$36\frac{1}{2}$
Chicago to Omaha, Nebraska	491	$24\frac{1}{2}$
Omaha to Bryan	858	43
Bryan to Ogden, Utah	233	$10\frac{1}{2}$
Ogden to Elko, Nevada, via Central Pacific R. R.	278	$12\frac{1}{2}$
Elko to Sacramento, Cal., via Central Pacific R. R.	465	31
Sacramento to San Francisco, via Western Pacific R. R.	117	$3\frac{1}{2}$
	3,353	$161\frac{1}{2}$

Thus a total distance of 3,353 miles is made, according to the present schedule time, in 6 days and $17\frac{1}{2}$ hours, actual time, by a traveler's watch, from which we deduct $3\frac{1}{2}$ hours difference of time, when going West, leaving the apparent time consumed in making the trip 6 days and 14 hours.

At San Francisco the mails will connect with the various steamship lines running on the Pacific, and may be landed in Honolulu in 9 days from that city, or $15\frac{1}{2}$ days from New York. They can reach Japan in 19 days from San Francisco, or $25\frac{1}{2}$ days from New York, or 33 to 34 days from Great Britain—thus beating the British mails sent via Suez, three to four weeks. The trip between Yokohama, Japan, and either Hong Kong or Shanghai, is readily accomplished by the Pacific Mail steamships in from five to six days, which, added to the time in reaching Japan, will give the through time necessary to reach either of the above named ports of China.

The mails for Australia, it is thought, will hereafter go via San Francisco. as the Australian and New Zealand Steamship Company intend transferring the terminus of their line, which has been running from Sydney to Panama, so as hereafter to run from Australia to Taluti, thence to Honolulu, and thence to San Francisco, making 28 days schedule time, which will give us monthly mail to Australia in 34 or 35 days through time.

STEEL-CAPPED RAILS.—A paragraph has been going the round of the press, stating that the Hartford and New Haven Railway Company had ceased laying down steel rails, for the reason of their "stiff, unyielding character." As rail stiffness is what our engineers have long been striving for, the reason given was rather odd, to say the least. We have never found a rail too stiff for a thirty-two ton engine, going at speed, and probably no one else has. The section of rail should always be heavy or stiff enough to prevent any deflection when the driving-wheel passes between the sleepers; if not, the wheels are constantly running up and down short inclines, producing that unsteadiness of movement and pounding that is so destructive to both rails and wheels. The rail is nothing but a girder, and the more strong and stiff it is, the safer and better it is for every purpose Any elasticity of the track should be applied in the superstructure below the rail. We understand that the Hartford Company has ceased laying down steel-capped rails for the reason that the officers desire to test their utility before further expense is incurred. They have some fifteen hundred tons in the track, and at present it is doing well. The principal objection urged against the iron rail covered with steel is, that the steel will flake off by wear. The makers, on the other hand, claim that their system of uniting the two is complete, and that the steel will adhere until worn off. The durability of steel-capped rails is a matter which requires more experience to determine, though a lot of Prussian make (Funcke & Elbers) laid on the Boston and Providence road are showing fine results. These rails are not made of Bessemer but of puddled steel, and the method of piling in manufacture differs from common practice, it being vertical instead of horizontal, so that the weld being perfect, any defect or want of homogeneousness in the material will show itself in the head by a depression, instead of flaking off or laminating is seen in many makes of iron rails. The Prussian rail can be cut and notched in the flanges without any fear of a succeeding fracture at the point cut, and there is equal security against fracture at the bolt holes for the fish-plates. We must confess to some doubt as to the wearing qualities of an iron rail with a Bessemer metal cap shrunk on around the head, the difficulty being in getting a good weld; but we understand that it has been done with promise of good results. Our railway companies are making money enough to allow them to make a fair trial of all the new devices and we trust that they will do so, so far as they can without impairing the safe character of travel.—*Railway Times.*

THE SWISS ALPINE RAILWAY.—Besides the great engineering triumphs of the nineteenth century—the Suez Canal and the Mont Cenis—another work of no less magnitude is now claiming universal attention, namely, the Mont Saint Gotthard Railway. After the Prussian and Italian ambassadors notified lately to the Swiss Confederation the material support of their respective governments towards that undertaking, a conference was assembled at Lucerne for the purpose of taking the initiative in the matter, and to arrange a financial programme. Dr. Alfred Escher, the eminent Swiss statesman and railway director, reported that of the necessary capital—6,500,000*l.* sterling—2,500,000*l.* will be found in Italy, 2,000,000*l.* in Germany, and 2,000,000*l.* in Switzerland, these sums being composed of 3,600,000*l.* subventions, 1,000,000*l.* in obligations, and the rest in shares, the greater portion of which has already been subscribed for in Switzerland.

In the construction of the Saint Gotthard line the project, adopted by the Italian commission, will be principally adhered to. This project includes a perfectly straight and nearly level tunnel of $9\frac{1}{4}$ miles in length, the northern tunnel mouth at Goeschenen will be 1,100 meters, the southern at Airolo 1,130 meters, and the tunnel summit 1,137 meters above sea level; and this tunnel the contractor of the Mont Cenis tunnel has offered to execute in eight to nine years, including steel rails, for the sum of 2,480,000*l.*

Another project, proposing a surface line, rising at the rate of 1 in 20, to 1,800 meters' height, has been condemned, as not affording that expeditious, safe, and economical working as the lower line with long tunnel. This consideration has carried all the more weight with it, as the future Swiss Alpine Railway will have to compete with the Mont Cenis, Brenner, and the French Mediterranean lines. It has been stated that on this latter line, having no steeper gradients than 1 in 200, the working expenses of one ton net are only one farthing per kilometer, while the carriage of one ton net on gradients of 1 in 20 would cost four times as much, or one penny per kilometer; and, moreover, the surface line being double the length of the lower line, the working expenses would accordingly be in the ratio of 1 in 8. The lines connecting the Saint Gotthard tunnel with the Swiss and Italian railway system will still, however, present some heavy gradients and sharp curves.

We understand the attention of the Saint Gotthard Commission has been directed to Mr. Fairlie's double-bogie engines, and that gentleman's plans have been regarded with much favor and interest.—*Engineering.*

Electric Lights on Railways. — According to the American journals a novelty in railway management is to be introduced by the Erie Company, who propose to illuminate the whole line of that road at night by electric lights at the ferries, in the tunnels, on all dangerous curves, and on every engine. Mr. E. C. Morse, who has charge of the matter, states that he has made several important improvements, among others a plan for preserving the carbon points from wasting away and keeping them for months in good condition, a self-sustaining battery, and an invention by which the turning of the wheels of the engine shall collect electricity for use in illumination. There will be a light at each end of the ferry, which it is believed will make a collision practically impossible on the darkest and foggiest night. Even with the diminution of light caused by the jarring of the locomotive, it is estimated that the head-lights will show the track to the engineer on a straight line for three miles. More welcome, however, than any announcement of material improvements would be a notification in the cause of public morality that the managers of this line could be brought to a condition of responsibility for the pecuniary claims of the shareholders.—*Engineering.*

Speed and Power of Locomotives.—The *speed* of an engine depends on the rapidity with which its boiler can generate steam. One cylinder full is required for each stroke of each piston. Each double stroke corresponds to one revolution of the driving wheels and to the propulsion of the engine through a space equal to their circumference. Wheels seven feet in diameter pass over twenty-two feet in each complete revolution. To produce a speed of seventy-five miles an hour, they must revolve exactly five times in a second; and to effect this revolution, each piston must make double that number of strokes in that time, and consume ten cylinderfuls of steam. The *power* of an engine in drawing loads depends on the pressure of the steam, which is usually about 120 pounds on the square in. It is also limited by the adhesion between the track and the driving wheels, which is proportional to the weight pressing on the latter; so that instead of the weight being an obstacle, it is one of the principal elements of power. The tractive power of an engine of 40 tons, with 32 resting on the drivers would be about 4 tons —*American Artisan.*

New Railways in the United States.—It is believed that at least 5,000 miles of new railroad will have been opened in the United States in the course of the year 1869. Already the returns show a mile to every 876 of the population.

The Reading Railway Co. are making very superior iron rails at their own mill by simply putting plenty of work on the iron.

NEW BOOKS.

A Practical Treatise on Modern Screw Propulsion. By N. P. Burgh, Engineer. London: E. & F. N. Spon, Charing Cross. 1869. New York: D. Van Nostrand, 23 Murray street.

Mr. Burgh's important treatise on the screw propeller, the publication of which in numbers was commenced nearly two years ago, now lies before us as a handsome volume. We have already referred at some length to the first chapters of the book, and it is therefore unnecessary now to consider their contents again. They consist, it will be remembered, essentially of an opening chapter by Mr. Burgh, and a historical introduction from the pen of Mr. G. B. Rennie, M.I.C.E., which is contained in seventeen pages. We are not aware of the existence of any historical notice of the screw propeller at once so short and so good, and having said this much we fancy we have said all that is requisite to indicate the character of the chapter. Starting from this point we find next a treatise or chapter—which the reader will—on the geometry of screw propellers in general, written by Mr. Burgh, and this is followed up by a history of the Griffith's propeller, written by Mr. Griffiths himself; a chapter on its geometry by Mr. Burgh, and one on the geometry of the paddle wheel by Mr. Barclay. Here we must stop for the moment, as we do not intend to publish a list of all the chapters in the book; the more important we shall refer to in their proper order as we go on. The distinguishing feature of the volume is, that a large portion of it has been written by men of enormous practical experience. Besides the chapter by Mr. Rennie already referred to, we find here distinct, compact, neatly written treatises, based on special points of practice, from the pens of such men as Mr. Griffiths, Mr. John Penn, Messrs. Maudslay and Field, Messrs. Dudgeon, Captain Symonds, Mr. Langdon, etc., etc. The book, as a whole, therefore, constitutes an encyclopædia of the screw propeller, possessing the immense advantage over all other works on the same subject that it is written not by one man, but by several who are specially qualified to express the most valuable opinions, and to supply the most valuable information which is attainable. This fact alone would suffice to establish the character of the volume as the best work in existence on the screw propeller; but, in addition to this, a single glance at the volume will show that it contains a set of engravings which are absolutely unique. They represent to a fair scale, not the screw propeller of the past, not the screw propeller as it exists in patent office specifications, not as it lies in the brains of inventors, but the screw propeller, and every detail connected with it, as it exists in the naval and mercantile marine of Great Britain, and as it has come from the hands of the very best mechanical engineers in the whole world. It would be quite possible to take these engravings into any drawing office, and to prepare from them a set of drawings by the aid of which the designs "depicted"—to use a favorite word of Mr. Burgh's—could be carried out in practice. This is the highest praise which any engraving can receive, and, knowing this, we award it cheerfully to Mr. Burgh's lithographs.—*The Engineer.*

The True Basis for the Construction of Heavy Artillery. By Lynall Thomas. London: F. Taylor and Francis, Red Lion-court, Fleet street, 1869.

A Course of Six Lectures on the Chemical Changes of Carbon. By William Odling, M. B., F. R. S., Fullerian Professor of Chemistry, Royal Institution. Delivered before a Juvenile Auditory at the Royal Institution, Christmas, 1868–'9. With Notes by Wm. Crookes, F.R.S. London: Longmans, 1869. For sale by Van Nostraud's.

Dr. Odling's Christmas Course of Lectures for Juveniles, at the Royal Institution, were no doubt attended by some of our readers, who, though childhood's time is gone with them, consented under the circumstauces to the imputation of being still only big boys. To these and to all others who were present at the delivery of the lectures, the permanent record of them by Mr. Crookes will, we are sure, be very welcome as a *souvenir* of some happily spent hours. To listen to a lecture in which the nature of some group of natural phenomena is set forth in a form clear and distinct to the entirely uninitiated by a master hand, has always been to us a keen pleasure. Dr. Odling possesses in a special manner the power of comprehensive exposition, which, united with enviable qualities of voice and manner, renders his teaching unusually attractive.

The title of this course of lectures—*The Chemical Changes of Carbon*—only imperfectly indicates their subject-matter. For the benefit of those—necessarily the great majority—of our readers who did not hear the lectures, we will briefly enumerate the principal matters touched upon the method of the course. Concerning the method, it is that of passing from one fact to some other to which it naturally leads, making the selection according to the object in view—that is to say, it is the common method of passing from the known to the unknown. This method has been, however, more extensively followed in these lectures than is usual. Mr. Crookes in his preface to the lectures says, and we quite agree with him:

"A remarkable feature in these lectures is the fact that every term made use of is defined as it occurs, and the oral definition is supplemented by a clear and decisive experimental illustration."

Of carbon itself, its three forms are described—namely, charcoal, graphite, and diamond, while of its compounds the three following are selected—carbonic gas (carbonic acid), carbonous oxide (carbonic oxide) and carbonic disulphide (sulphide of carbon), to which we might add marble from the considerable incidental notice it receives. The carboneted hydrogens are not studied. The physical and chemical properties of the atmosphere are pretty largely treated of, and the phenomena of combustion, oxidation and reduction, and of the diffusion of gases. The solubility of gases in liquids, the conversion of gases into liquids, and the reconversion of the latter into gases with the attendant phenomenon of the production of great cold are also fully illustrated. So, too, is the remarkable power of charcoal of absorbing gaseous bodies and withdrawing substances from solution.

Mr. Crookes has added an appendix of notes which is very useful. It might seem, at first, that a studiedly simple exposition ought to need no explanations, but it must be remembered that facts may be adduced to illustrate a point, and do so without ambiguity, at the same time that many particulars concerning them may receive no attention. But these facts after they have served the purpose for which they were brought forward, may still excite inquiry in the mind as to other things about them. Mr. Crookes' notes meet such a curiosity. To both the author and the editor of these lectures the friends of scientific education must feel themselves indebted.—*Scientific Opinion.*

The Soldier's Pocket-Book for Field Service. By Colonel G. J. Wolseley, Deputy Quartermaster General in Canada. For sale by Van Nostrand.

When, from time to time, we read of the publication of some military work of instruction, our first impulse is to look out in the Army List for a detail of the author's services, as we have a natural repugnance to wading through volumes of theories by men without war experience, who can only tell us what they think active service ought to be. Strange to say, almost all our military works are by such men. Many of their books are clever, and calculated to turn attention to military subjects, but all lack the clear ring of the practical about every page, bearing upon it unmistakable evidence that what it contains is either a personal theory or an extract from some foreign author. Whatever may be the shortcomings of the little handbook whose title heads this article, it is, at least, by one who is entitled to instruct us in war. Indeed, we know of no officer whose varied experience of active service and upon the staff fits him so well to be the author of such a work. It is intended, he tells us in his preface, for all three arms and for men of every rank; that the information it contains is the result of his own personal experience, and that it is, therefore, of an essentially practical nature. Throughout its pages there are extracts from our military regulations. It is a curious circumstance that there is but little in them which is applicable to war. If a man, from some unknown country, were to pore through them, it is possible he might imagine that to "march past in slow time" was *the* object for which our Army existed. War is, doubtles, alluded to occasionally, but only as a possible contingency. The consequence is, that when officers—even those of many years' standing—find themselves for the first time standing in front of an enemy, they are at a loss how to act. When such men are in command of regiments, unless they are of great common sense and sound judgment, the service must suffer from their endeavors to carry out in the field the routine of barrack life, to which noble (?) subject so much space is devoted in all our official regulations. Colonel Wolseley's handbook will be to all such men a *vade mecum* of great value.—*Army & Navy Gazette.*

Official Railway Manual of the Railroads of North America for 1869–'70; showing their Financial Condition, Mileage, Cost, Earnings, Expenses and Organizations; together with a List of the Railroads of the World. Compiled from Returns furnished by the Companies. By James H. Lyles, of Lindsay. Walton & Co., 56 and 58 John street, New York.

This is a complete directory in everything relating to the Railways of the United States. It contains, besides a full statement of the finances and engineering particulars of each road, full lists of the directors and all officers, statements of the rolling stock and locations of the shops, information as to the election of directors, and a great deal of miscellaneous information of value to persons in any way interested in railway matters.—*American Artizan.*

MÉMOIRE SUR LA COMPOSITION CHIMIQUE DES MONNERIES NÉERLANDAISES ET SUR LA VOLATILISATION DE L'ARGENT. Par A. D. VAN RIEMSDIJK, Docteur des Sciences. Pp. 38.

This is an abstract, reprinted and separately published, from the "Archives Nécrlandaises," vol. iii, 1868. The larger work was written and published in Dutch early last year. It treats on a subject which can only satisfactorily be experimentally studied in a well-arranged Mint; and Dr. Van Riemsdijk, having that opportunity at Utrecht Mint, has thoroughly gone into matters with great zeal and industry. It will be clear, even to a casual observer, that divers chemical changes must of necessity occur to the alloys intended to be converted into coin during the many operations the alloy is submitted to before it leaves the works; it is simply impossible to melt together two metals, and afterwards again anneal the partly rolled out bars, without some chemical change being called into play, The various changes and effects, also, of the blanching and cleaning of the alloys have been studied and experimented upon by the author. He has extended his experiments not only to Netherlands, but also to Belgian, French, Peruvian, Bolivian and Chilian silver coins. Gold coins are not made at the Utrecht Mint as current Netherland coins; hence no experiments were made with gold. The author has also investigated the capability of silver, both pure and alloyed, for absorbing and occluding various gases, especially hydrogen and oxygen gas. On the whole, those who work in silver on the large scale, and are interested in the real composition and constitution of the alloyed metal, will find in this paper many very interesting and useful hints, while assayers will certainly read with pleasure the information contained in these pages.—*Chemical News.*

BIBLIOTHÈQUE DES PROFESSIONS INDUSTRIELLES ET AGRICOLES. Edited by EUGENE LACROIX. Paris: 54, Rue des Saints-Pères.

This latest scientific publication of M. Eugène Lacroix—the indefatigable editor of the *Annales du Génie Civil* and the *Etudes sur l'Exposition*—is calculated to considerably enhance, not only his own already well-earned reputation, but also those of the able contributors by whom he has been assisted. Although the last-mentioned work (*Etudes sur l'Exposition*) is not quite finished, there being one more volume and the index unpublished, M. Lacroix has already published several volumes of a new work, entitled *Bibliothèque des Professions Industrielles et Agricoles*, which appears to embrace a large field of subjects. Thus the *Théorie Mécanique de la Chaleur*, which is translated from the German of Professor Clausius into French by Dr. Folie, is a very elaborate and complete treatise upon this difficult subject, but one which is most important to engineers and all interested in the economy of fuel. The second part of this treatise relates to the relation of the mechanical theory of heat to electricity. The next volume is upon a different subject, being an *Essai sur l'administration des enterprises industrielles et commerciales,* by M. Lincol, and will be found of great assistance to capitalists and managers of commercial enterprises of every description. A chapter entitled "Du rapport entre entrepreneurs et employés," in which the rights and obligations of employers and employed is considered, is well worthy the attentive perusal of both classes there indicated.—*The Artizan.*

PRACTICAL SPECIFICATIONS OF WORKS executed in Architecture, Civil and Mechanical Engineering, Road-making and Sewerage; to which are added a series of useful agreements and reports. By JOHN BLENKARN, C.E., and Architect. Philadelphia: H. C. Baird, 1868. 8 vo. pp. 416.

Projectors of promising and important enterprises are not always wide-awake as to the financial details essential to the beginnings of carrying out. Here lies the wide gap between all the fine plans that are conceived, and their execution. There exists, accordingly, a class of more practical and less presuming engineers, who are sometimes called contractors and sometimes boss laborers, and whose care and specialty is to be clear on all questions of cost, and specification in detail. The present work is intended to assist engineers and architects with examples and methods, chiefly of specifications accompanied by plans, in the acquisition of such all-important practical points in the business of an engineer in full reputation and activity, as could otherwise be acquired only by many years experience.—*Mining and Scientific Press.*

ON MECHANICAL SAWS. From the Transactions of the Society of Mechanical Engineers, 1867. By S. W. WORSSAM, Jr. Illustrated by sixteen large folding plates. Philadelphia: Henry Carey Baird, Industrial Publisher, 406 Walnut street. Price $5.

The saw, there is good reason to believe, is one of the oldest of all the instruments used in the mechanical arts; and it has certainly played a more conspicuous part than any other in the history of civilization, though it is a subject on which little has been written. Mr. Worssam's book treats more particularly on the several kinds of saws driven by steam or other power—reciprocating, rotary and endless band. It discusses the various forms of teeth, with very copious illustrations; gives some valuable information on sharpening and setting, and on gauges, files and saw-sets. It also gives illustrations of saw sharpening machines. The work is a valuable addition to industrial literature.—*American Artizan.*

THE ELEMENTS OF THEORETICAL AND DESCRIPTIVE ASTRONOMY; for the use of Colleges and Academies. By CHARLES J. WHITE, A. M., Assistant Professor of Astronomy and Navigation in the U. S. Naval Academy. Philadelphia: Claxton, Remsen & Haffelfinger, 819 and 821 Market street.

This is a comprehensive though concise manual of the principles of astronomy, adapted to colleges and the higher grades of academies. It contains the latest information on every branch of the subject, including the recent interesting discoveries made by the aid of the spectroscope. We recommend it to those who wish to know the general principles and present state of the science of astronomy.—*American Artizan.*

THE OPERATIONS OF WAR. By Colonel EDWARD BRUCE HAMLEY, C.B. Blackwood. For sale by Van Nostrand, New York.

In closing a long review of this volume, the "Army and Navy Gazette" says: "We feel that Colonel Hamley has done good service by its publication; he has critically considered the revolution that has taken place within so brief a period in the operations of war; has weighed the consequences calmly and deliberately, and has offered his conclusions in a manner calculated to command attention."

THE RUTHVEN HYDRAULIC PROPELLER versus THE SCREW AND PADDLE. London: J. Haddon & Co.

This pamphlet, which the author has been too modest to own, proceeds from the "Ruthven Hydraulic Propeller office," and, as might be expected, is devoted to the task of proving that the Ruthven propeller is the best method of propulsion in existence. In order to accomplish this feat it has to be demonstrated that the Admiralty experiments with the hydraulic-propelled *Waterwitch* and the screw vessels *Viper* and *Vixen* were erroneous. This is done by asserting that in the *Waterwitch*, at the time of the trials there was an enormous leakage of steam, although Mr. Murray could not discover it. Considering the eminence of Mr. Murray in his profession, and also that the engines were one of Mr. Dudgeon's best jobs, it requires a considerable amount of credulity to accept the assertions contained in this pamphlet.—*The Artizan*.

A TREATISE ON ROPE MAKING, AS PRACTICED IN PRIVATE AND PUBLIC ROPE YARDS; with a Description of the Manufacture, Rules, Tables of Weights, etc., adapted to the Trade, Shipping, Mining, Railways, Builders, etc. By ROBERT CHAPMAN, formerly Foreman to Messrs. Huddart & Co., Limehouse, London, and Master Ropemaker of H. M. Dockyard, Deptford. Revised edition. Philadelphia: Henry Carey Baird, 406 Walnut street. 1869. Price $1 50.

Besides containing calculations and other information indispensable to the practical rope-maker who desires to thoroughly understand his business, this little book contains much that should be known in the various trades and professions in which cordage is used.—*American Artizan*.

THE MECHANIC. Vol. 1, No. 1. New York. C. Rogers & Co., 229 Broadway.

This a new weekly containing some dozen pages of matter and many wood cuts. The prospectus says: "That such a publication is required may be seen from the fact that, by the census of 1860, there were not less than 140,433 manufacturing establishments in the country, employing 1,311,246 persons, of whom 1,040,349 were males. Judging from the number of applications for patents there must be from 75,000 to 100,000 active inventors in the country, most of whose improvements are specially adapted to manufacturing processes and products."

THE MILLING JOURNAL AND CORN EXCHANGE REVIEW. New York: J. Q. Nolan & Co., 95 Liberty street. June, 1869.

This monthly journal has been enlarged and improved, and ought to be read with interest, we think, by all men in the department specially appealed to, and by artizans in general.

THE REPORT OF THE STATE ENGINEER OF NEW YORK ON RAILROADS FOR 1868.—We have in previous numbers of this Magazine quoted in full Mr. Sweet's able article on the manufacture and endurance of iron and steel rails and on permanent-way in general. Probably no governmental paper containing so much practical knowledge of the requirements of modern permanent-way, has ever been given to the profession. But this treatise is a very small part of the State report. The particulars of cost, management and working, for all the roads, are given in great detail.

MISCELLANEOUS.

COAL MINE DISASTERS IN THE UNITED STATES.—The more important recent disasters are thus recapitulated in the "New York Times":

In five years, there have been but six accidents worthy of mention, apart from the one which has just occurred; and two of these are of a nature not peculiar to mining. Thus, at Phœnix Colliery, Schuylkill Haven, on the 23d July, 1864, while a car loaded with miners was being drawn up the incline, the chain broke, the car was precipitated downward, and the twenty-one occupants of the car were killed. In July of the following year a flood occasioned by rain imprisoned the men employed in a coal mine at Mahoning, Ohio, from Friday till Wednesday; they were rescued by drilling another shaft. On the 3d April, 1867, an explosion fired the Clover Hill Mine, Pennsylvania, and about seventy miners—all that were at work—perished. In this case there were two shafts, both of which were closed with the view of controlling the fire. In November of the same year Pine Ridge Colliery, near Wilkesbarre, was closed to extinguish fire-damp; when opened, after some days, an explosion took place. At Diamond Mine, Scranton, in March, 1868, twelve men were killed by the breaking of a hoisting chain. The next casualty of which we have any record occurred eleven or twelve days ago in the Pine Ridge Colliery, in the Wilkesbarre neighborhood. An explosion of fire-damp gave rise to the fire at the entrance of the mine, in which thirty men were at work. Their extrication alive would seem, from the published statements, rather the result of Providential incidents than of any help which man was enabled to render.

And now comes the greatest calamity of all—the fire in the Steuben Mine, and the almost certain suffocation of more than two hundred miners. In this instance it is believed that fire was communicated from the ventilating furnace to the woodwork at the bottom of the shaft; the flames rushed upward with frightful velocity, and at the surface reached a mass of wooden buildings, which no effort could save. Burning timbers and rubbish soon filled the shaft, and, as no second outlet had been provided, the fate of all in the mine appears as certain as it is horrible. When at length a passage was obtained, it was only to find the accessible part of the mine filled with poisonous gases.

AVELING & PORTER'S STEAM PLOWS AND STEAM ROAD ROLLERS.—At Beauvais, France, June 30th, Messrs. Aveling & Porter, of Rochester England, and 43 Exchange Place, N. Y., exhibited their Steam Road Roller and their Steam Plow. The Emperor and Empress of the French were present and devoted an hour to the examination of Messrs. Aveling's machinery. The Emperor expressed himself highly gratified with the various machines and presented Messrs. Aveling with a gold medal for their Steam Road Roller, and another gold medal for their steam plowing machinery, which at the special request of the Emperor plowed up a portion of the highway, and without breaking any part of the machinery.

WOODEN GAS PIPES.—A firm in Oshkosh, Wisconsin, has contracted to make 1,000,000 ft. of wooden tubes to lay down in that city for gas pipes. They are made of timber 6 in. square, bored in the same way as pump barrels.

Steaming and Rowing—An Engineering Parallel.—One of the most remarkable features of modern steam navigation is the general substitution of the screw for the paddle. Indeed, the screw steamer has nearly driven its rivals from the stormy Atlantic, where the merits of submerged propellers and heavy spars are most manifest, and is fast chasing them from more pacific waters the world over. The "Persia," which but fourteen years ago was considered the perfection of naval architecture, was last year sold for £15,000, to be changed from paddle to screw. Just as the Cunarders were experimenting with their first screws, the new French line to this country was started with paddle ships. One of them, the "Washington," which formerly steamed ten miles an hour with 96 tons of coal per day, has since been fitted with screws, and now steams 11.8 miles with 83 tons of coal; and the new ships of all Atlantic lines are invariably propelled by screws.

The greater economy of the screw ship with a given speed and load, or her greater speed with the same fuel, are not due entirely to the fact that the efficiency of her propellers as compared with that of paddle-wheels is less impaired by the rolling of the vessel—not entirely to the fact that the screw steamer, by reason of the submersion of her propeller and its indepencence of the rolling of the ship, can carry more canvass and can sail on her beam ends as well as on an even keel, as far as applying the engine power is concerned. Nor does the superiority of the screw ship lie entirely in her greater capacity for stowage, by reason of the greater compactness of her engines, nor yet in the improvement of her machinery for generating, superheating, distributing and condensing steam, since all these may apply equally to the paddle steamer.

One of the notable differences between the new practice and the old, both in ships and locomotives, is the high speed of piston adopted in modern engines. The paddle engine is a great lumbering, heavy machine, moving at the moderate speed suited to the paddle-wheel. The screw engine is compact, light and lively, and it pulls the quick stroke demanded by the screw. A horse power is 33,000 pounds lifted one foot in a minute, or one pound lifted 33,000 feet in a minute. Now the paddle steamer principle carried to excess would illustrate this law by lugging around the 33,000 pound weight, and lifting it a foot, while the screw steamer would be burdened only with the one pound, which it would lift 33,000 feet. The total power is the same, but while in the one instance, a large percentage of it is neutralized in carrying itself—in carrying the cumbrous enginery by which its great force works through a small space—in the other instance, the enginery is small and light, because it has only to transfer a small force through a great space, and speed does not weigh anything.

There are many illustrations of this law in practice. The old style of locomotives with immense driving wheels, big cylinders and ponderous parts, has given place to light-moving parts, small drivers and quick stroke. A small cotton cord running at 60 miles an hour through a machine shop does the work of cumbrous cranes crawling a few feet a minute.

This engineering law and these illustrations establish the correctness of the quick stroke adopted by the Harvard oarsmen as compared with the long, slow, beam-engine stroke of Yale. Speed is an element of power that weighs nothing. If some element that is ponderous is substituted for it, a part of the total power is lost in the machine itself. —*N. York Times.*

Brown's Patent Stop Valve, or Gate.—This is a sliding valve differing materially from, and having many advantages over the wedge valve. It is simpler, stronger, more effective, less liable to leakage, and more easily repaired. Its essential feature is a compound lever brace, or toggle-joint, which acts at the center of the gate, and at nearly a right angle with it. The pressure of the brace is very powerful, and having a center bearing, is distributed equally at every part, forcing the gate firmly to its seat; thus preventing that unequal bearing and consequent leakage, which in wedging valves is incident to imperfect adjustment, uneven wear, &c. The brace, though pressing powerfully, is instantly and freely relieved, for it moves through an inclined groove, and has a rolling motion at each end, thus avoiding all danger of sticking, as in wedging valves. The brace effects great pressure, and consequent tightness, with far less friction and wear than is possible with wedging valves. The gate is held gently to its seat by ribs in the box, so that as it moves, it clears the seat of any foreign substances which might otherwise get between the gate and seat and cause leakage, as in wedging valves; these ribs also relieve the stem from too great strain upon it. The valve is easily repaired, for the gate, brace and stem can readily be removed from the box without disturbing the pipe.

The small sizes, of bronze, are made unusually heavy, to prevent twisting, and of the best steam metal. The iron gates are also very heavy, and of a cylindrical and spherical form, to resist great pressures, and to prevent springing and leakage. It is as cheap as any other sliding valve, notwithstanding its great superiority in principle, construction and action. It is used by many of the largest works in the country, and is conceded by the most eminent engineers and machinists to be one of the best valves known.

Steam Hammers.—Messrs. Morrison & Co., of Newcastle-on-Tyne, some time ago made a very large steam hammer, on their patent principle, for the Aboukoff Steel Works, near St. Petersburg. The piston and piston rod form, of themselves, the hammer, and thus fractures now and then occur. To renew the piston rod, or hammer head, in wrought iron, costs £3,000, or, in puddled steel, £4,000. Messrs. Thwaites & Carbutt, of Bradford, are about to alter this hammer, putting in new standards, with ordinary piston, piston rod, and "tup."

Old and New Coal.—Our attention has been lately drawn to a curious observation which stands, as yet, as a fact without a sufficient reason. In one case, where hard coal is used in large quantities for purposes of me re evaporation, it appears that some which has been kept on hand in open piles for five or six months, is less effective by from 13 to 15 per cent than that freshly mined. A similar result, corresponding even in the percentage of deterioration, appears in another report from a smelting furnace. The deterioration from decrepitation, caused by absorption of water, is of course well known, but does not seem to apply to these cases.—*Jour. Franklin Inst.*

WOODEN AND CONCRETE PAVEMENTS.—Mr. Julius W. Adams, Chief Engineer of the Water and Sewerage Commission, Brooklyn, recently made the following report to the Board, which was adopted :

"The Nicolson pavement is too well known to require comment. It is extending in use in the Western cities, and although from the nature of the material, it cannot be expected to last as long as stone, yet its other acknowledged advantages commend themselves to a large class of our citizens.

The A. Miller pavement possesses, in my opinion, peculiar advantages over the Nicolson, as will be explained more particularly and at length hereafter, and I think the Board will be justified in adopting it, whenever they may have determined to use wooden pavement, as being equal at least to the Nicolson.

The McKenzie pavement has some merit, but it has some of the defects of the Nicolson to a greater degree than the latter, which may prove in practice to counterbalance its other advantages. A practical test is needed before its claims to being an improvement on the first-named pavements can be admitted.

The Williams pavement has an advantage in that it is prepared to be laid on a bed of concrete. It comprises in fact the concrete and wooden pavements, with a consequently increased cost. The merit claimed in the key of bituminous concrete is a fallacy, in my judgment, and is so far an experiment that until tested in practice I could not recommend the adoption of the plan by the Board.

The Miller pavement, with inclined blocks, experience has shown to be inferior to plans with the piles placed vertically, and is probably the least to be commended of any plan submitted to the Board.

Of the concrete pavements I have no evidence that either the Fiske or the Scrimshaw has any advantages, the one over the other. This pavement is extending abroad, but it has the merit in France of being composed of the native asphalt, which is not found in our country; and the imitations of it, composed of tar and gravel, it is known are very inferior to the native material. Laid on the present cobble pavement, properly repaired, it may give good results. The Hoyt pavement is a mere experiment, and possesses no merit that I can perceive over the Fiske or Scrimshaw. Neither of this nor of the remaining plans submitted have I sufficient evidence before me to justify my recommending them to the Board at this time."

DIFFERENTIAL PULLEY BLOCKS.—Messrs. Tangye Brothers, Cornwall Works, Smethwick, produce in large quantities, as a special branch of manufacture, Weston's differential pulley blocks, of which since 1859 not less than 30,000 have been turned out here. These are the only pulley blocks yet made in which the weight is supported without risk of running down while the cord or chain is hanging loosely. The multiplication of power also can be carried to almost any extent with an exceedingly small amount of friction. These blocks, besides their extensive use in all warehouses and manufactories, have found several special applications. While recovering from his illness in 1865, the King of the Belgians was accustomed to ascend from one floor of his palace to another by means of these blocks, a suspended couch being provided, from which his Majesty, with very slight exertion, could raise or lower himself at pleasure. In a note to the inventor, General Garibaldi recommended their use for remounting artillery thrown down on the battle field. The watchman on the lofty fire observatory at Hodges' Distillery, in London, raises himself easily and rapidly to a height of 135 ft. At an *abattoir*, near Brussels, 120 pairs are used in hoisting and hanging the carcasses of the slaughtered beasts. Prince Napoleon in person purchased a pair at the Battersea Agricultural Show for use on board his yacht. In Borneo they are attached to trees overhanging the coast, for loading vessels. They are also largely used in Cornish mines. They suspend chandeliers in public saloons. They are fitted on board the Royal Oak and the other iron-clad steamers. They lift the top of wagonettes and coach-houses, and, in short, wherever lifts are required with complete security in raising and lowering, the differential pulley blocks are employed with obvious advantage.—*Cor. Engineer.*

THE PATENT LAWS.—Resolutions were recently passed by the Inventors' Institute of Great Britain, to the following effect: that the inventor was entitled to remuneration for his labor, expenditure and skill as much as the author or artist to copyright for his book or work of art; that capital would not be embarked in promoting inventions unless profitable return for such capital is assured by the operation of law, such as is done by the existing patent law; that a good system of patent law tends to foster the trade and industry of the country, and to maintain its industrial position against the active pressure of foreign competition; that working men are especially interested in supporting the present law, by which they can not only safely exhibit their inventions in public, but reap the fruits of improved education and increased application of inventions.

SHIPPING OF GREAT BRITAIN—In the year 1868, the registered shipping of the United Kingdom (exclusive of river steamers) employed in our home and foreign trade, comprised the unprecedented number of 22,250 vessels of 5,516,434 tons, employing 197,502 men, exclusive of masters, viz: 20,525 sailing vessels of 4,691,820 tons, employing 153,840 men, and 1,725 steam vessels of 824,614 tons, employing 43,662 men. At the end of the year there stood registered as belonging to the United Kingdom 28,444 vessels of 5,780,530 tons, viz: 25,500 sailing vessels of 4,878,236 tons, and 2,944 steam vessels of 902,297 tons. This is the highest tonnage ever recorded. There was built and registered in the United Kingdom in 1868, 879 sailing vessels of 300,477 tons, and 232 steam vessels of 79,096 tons.

WAVE POWER.—An engineer of New York proposes to employ the waves of the ocean as a motive power for running mills, factories, &c. His plan is to build on the beach (at Long Branch, Rockaway, or elsewhere) a dyke several hundred feet in length, against which the waves of old ocean are privileged to break as wildly as they will, but are not to be allowed to recede. In the sea face of the dyke are the openings of conduits which conduct the water to a reservoir within the dyke. A canal from the reservoir re-conducts the water, by a circuitous route, to the ocean, to turn on its way the wheels of as many mills as can be built on the canal banks.

Deep Sea Soundings.—At a meeting of the New York Association for the Advancement of Science and Art, held June 14, Mr. Livingston Morse exhibited his recently invented device for taking deep sea soundings without the inconvenience and delay incident to the use of ordinary sounding lines. The apparatus is termed a "bathometer," and consists in a hollow cylinder of wood or sheet-metal containing a number of hollow glass spheres, which, being filled with air, constitute the floats by which the device is caused to return to the surface of the water after its descent to the bottom. The cylinder is ballasted in such a way that it will maintain an upright position in the water, and has a detachable weight affixed to its lower end. When dropped overboard, the weight carries the apparatus to the bottom, whereupon, by an automatic contrivance, the weight is detached and the cylinder rises to the surface. The time of ascent and descent being about equal and the rapidity of movement being ascertained by previous experiment, the period of submersion is a tolerably accurate index of the depth. The inventor, however, does not intend to rely upon this, but has provided the apparatus with a peculiar registering device by which the pressure of the water, and consequently the depth, is accurately recorded. The instrument is furthermore so contrived as to bring up a specimen of the bottom of the sea at the point where it struck.—*Am. Artizan.*

Water Deprived of Air—Boiler Explosions.—In reference to the well-established fact that water, after having been deprived of air as much as possible, either does not boil at all when heated, or does so with violent, sudden starts and concussions, some experiments have been made by Kremers, who observed that, in order to assist in expelling air from water, the addition of spirits of wine, in the proportion of one part of the latter to three of the former, is very useful. He cautions against a danger which exists when such a mixture is heated too rapidly, since it is very apt to boil over, especially after a portion of the spirit has evaporated. It is rather curious that, though both the water and spirits of wine were pure, the mixture when boiling should assume a greenish-yellow hue, which disappears again on cooling. The boiling-point of the fluid easily becomes as high as 109°. As a result of a large number of experiments, the author finds that water, as fully deprived of air as possible, may be heated as high as from 180° to 200° C., without boiling permanently.—*Quarterly Journal of Science.*

A New Freezing Mixture, which appears to be of considerable interest, has been described by Mr. Galletly. When citric acid and crystallized carbonate of soda, in powder, are stirred together, the mass gets into a pasty state, and in a short time becomes quite liquid. If equivalent proportions of the substance are used, the temperature falls from 60° F., to 8° F. The mixture, for a time, is full of air-bubbles, but soon becomes a clear, dense, syrupy fluid. The fluid obtained by mixing the powders becomes solid in a day or two standing in a corked jar. The solid mass has the appearance of set plaster of Paris or damp chalk. The addition of a very little water appears to prevent this setting into a solid mass; but the chalky-looking citrate lies a long time in cold water without being dissolved.—*Quarterly Journal of Science.*

Platinizing Copper.—In order to obtain a platinizing fluid capable of platinizing copper, yellow metal, and brass, add to a moderately concentrated solution of chloride of platinum, finely powdered carbonate of soda until effervescence ceases, next some glucose, and afterwards just so much common salt as will cause a whitish-colored precipitate. When it is desired to apply this mixture for platinizing, the objects to be treated are placed in a vessel made of zinc and perforated with holes, the vessel is then placed, with its contents, for a few seconds in the mixture just described, which, just previous to using, should be heated to 60° C. On being removed from the zinc vessel, the objects are to be washed with water and dried in saw-dust.—*Quarterly Journal of Science.*

Self-Registering Compass.—An instrument of this description, devised by Captain Albini, of the Italian Navy, and constructed by Messrs. Elliot Bros., of London, was exhibited at the late Conversazione of the Institute of Civil Engineers. It consists essentially of a compass, with a card carrying types at its periphery in such a way that, by an attached clockwork, an impression may be made at stated intervals on a band of paper, from whatever type is over a certain point at these times. Thus clearly an almost continuous record of the ship's course may be automatically produced.

Water Ballast Road Roller.—Messrs. Ames & Barford, of Peterboro', England, are building rollers, water tight, so as to be filled with water to increase the pressure when necessary. Besides securing in one roller a one, two, or three-horse implement at pleasure, the increased weight is employed directly on the surface of the land, with the highest percentage of crushing power, yet without increasing the friction on the bearings (and consequently the draught of the implement), as is the case when the old clumsy plan of loading the frame is resorted to.

Ventilation, Food and Health.—General Morin, in giving an account at the Academie des Sciences of the successful application of his ventilating apparatus in a large weaving factory employing 400 workpeople, and in which were lighted 400 jets of gas, observed that its advantage might be judged of from the fact that during October, November and December, 1867, when the ventilation was defective, only 15,000 kilogrammes of bread were consumed, while, during the same months of 1868, after it had been improved, 20,000 kilogrammes were required, being a gain of 25 per cent for the health and vigor of the operatives.

Wasted Coal Dust.—In Great Britain the quantity of coal dust remaining unemployed is calculated at 28,000,000 tons. Various methods have been attempted to convert it into useful fuel by compressing it into cakes, but the operation is not sufficiently remunerative. In Belgium they follow another plan, which seems to answer better. They mix coal dust with eight per cent of tar, and then press it into cakes, which are found to make excellent fuel for steam engines.

Artificial Lightning.—Professor Pepper has recently added to the apparatus of the Polytechnic Institution a monster induction coil, which furnishes a spark, or rather flash of lightning, 20 inches in length.

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BOILER EXPLOSIONS.

ON THE OVERHEATING OF FURNACE CROWNS AND OTHER BOILER PLATES WHEN COVERED WITH WATER.

Report of Mr. FLETCHER, Engineer to the Manchester Steam Users' Association.

From "The Engineer."

Every one at all conversant with the working of boilers is aware that when they are allowed to run short of water, the furnace crowns are apt to become overheated, the plate to be bulged downwards or otherwise distorted by the pressure of the steam, and in many cases to be rent, from which cause explosions frequently arise. This is admitted on all hands, and the *rationale* is so simple that the whole must be at once apparent.

It is not, however, by any means so generally known that furnace crowns may be overheated and bulged out of shape—sufficiently so in some cases to cause an explosion—even when they are covered with an ample supply of water. Such, however, is unquestionably the fact, and I wish specially to call attention to the subject on the present occasion.

Overheating of boiler plates when covered with water has been found to arise from two causes—one, the too local action of an intense fire, the other the character of the feed-water.

Injury from intense firing sometimes occurs to boilers heated by the flames passing off from separate furnaces constructed of fire brick, as in the case of puddling furnaces at iron works, when the flames are too frequently allowed to impinge directly upon the boiler, in consequence of which steam is generated so rapidly that the water is driven off from the plates, and overheating ensues. This is more especially the case where the heating surface is a vertical one, so that the steam on rising forms a separate film between it and the water. Two explosions resulting from this cause may be referred to. One of these occurred at an iron works on the 9th of February, 1865, to an externally fired boiler of the upright furnace class, heated by the flames passing off from two puddling furnaces, as well as from a large fire grate. The particulars of this explosion were given in the Association's "Monthly Report" for February, 1865. Another explosion of a similar character occurred on the 7th of February, 1866, to a plain cylindrical egg-ended boiler, heated by the flames passing off from a mill furnace at a works employed in the manufacture of angle iron. Details of this explosion will be found in the Association's "Monthly Report" for February, 1866.

It is desired, however, on the present occasion to call attention more especially to those cases in which overheating of the plates, whether in externally or internally heated boilers, has occurred simply through the character of the feed-water, and not from any peculiarity in the mode of firing. The feed-water which is found to be more particularly productive of overheating is highly impregnated with carbonate of lime. It forms but little scale, and that seldom thicker than an egg shell, though perhaps in some cases it may be nearly equal to one-eighth of an inch. It deposits, however, a good deal of fine flour or dust, which is generally of a lightish color. As this dust is quite loose, a good deal of it is floated away with the water when the boiler is emptied, while the remainder is readily washed out, so that on account of the ease with which it is removed, and the light character of the scale, it frequently escapes attention. If grease be introduced into boilers in which this deposit is formed, the furnace crowns are found to give way, the plates to bulge downwards, and leakage to take place at the seams of rivets. The distortion of the furnace plates, however, does not, as a rule, take place suddenly; on the contrary, the crowns come down very gradually, progressing little by little day after day, though hard firing in many cases has an immediate influence. Grease is introduced into boilers in various ways. The feed-water is frequently heated by blowing the exhaust steam from the engines upon it, so that the grease in the cylinders is carried with the feed-water into the boiler, while, in addition, the discharge taps from the cylinders sometimes blow into the cistern from which the feed-pump draws, so that the boiler gets all the engine sewage. Blowing the exhaust steam upon the feed-water has another effect beside the introduction of grease. It is sometimes lost sight of how much of the deposit formed within boilers is lifted out of the water by the steam and carried through to the engines, and thus disposed of either through the exhaust pipe in high-pressure engines, or in the hot well in low-pressure ones. When, therefore, the exhaust is blown upon the feed-water, this deposit is returned to the boilers, and a constant accumulation takes place, more especially if blowing out be neglected. That the steam lifts the deposit, and carries it along with it, is clear from the fact that it is frequently manifested at the glands and other parts of the engines, and also is heaped up in the steam dome when there is a shelf on which it can accumulate. These shelves are formed when the shell plate at the base of the dome is not cut away to its full size. This forms an eddy in the current of the steam, and leads to the deposit being dropped on the shelf plate, as just stated.

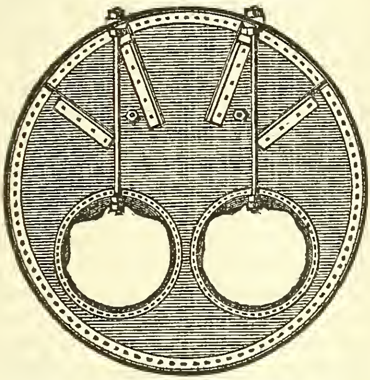
With regard to the manner in which this floury deposit affects the plates over the fire and leads to their injury, it does not appear to be necessary to suppose that this deposit becomes heaped upon the plates in order to lead to their overheating. It is doubtful whether it settles at all as long as the boiler remains in active work; while, were it to do so, it would settle where the ebullition was the least violent, and thus not on the furnace crowns of internally fired boilers. Possibly this fine floury deposit, by thickening the water, interferes with the due escape of the globules of steam, so that they are kept longer in contact with the plates over the fire than they should be, and thus the intimate contact of the water with the plates becomes interrupted, and overheating is produced. This may perhaps be illustrated in the following way: Clear water placed in a clean saucepan may be briskly boiled over a fire without foaming over, but if a little meal be dropped into it, or the water exchanged for milk, the globules of steam are no longer able to escape freely, and in their struggle they upheave the whole mass, and vomit a portion of it into the fire. Such is thought to be somewhat the action that takes place within a boiler charged with this fine floury deposit. The globules of steam imprisoned in the water lift it from the plates in their struggle to escape, and thus gradual overheating takes place in proportion to the character of the water and the intensity of the fire.

I am not desirous, however, of entering too minutely upon the precise manner in which this floury deposit leads to the overheating of the plates; suffice it to say that the results are indisputable, that numbers of boilers have been injured by it, and whatever may be the precise *modus operandi*, it appears to have the power of preventing that intimate contact of the water with the plates which is essential for carrying off the heat with sufficient rapidity, so that although they may not be made red hot, yet they become sufficiently overheated to lose a portion of their tenacity, when bulging under pressure ensues. Numerous instances of this have come before my notice, the particulars of some of which may now be given.

No. 1. The first of the cases that may be referred to was met with about the close of 1862, and occurred to a boiler fed from a well sunk near the river Mersey, in the neighborhood of Birkenhead. The boiler was of the ordinary Lancashire class, having two furnace tubes in which the fires were placed, while its length was about 20 ft., its diameter 6 ft. 6 in. in the shell, 1 ft. 10½ in. in the furnace tubes, and the load upon the safety-valve 40 lbs. per square inch.

This boiler had been found to give way again and again at the furnace crowns, the plates bulging down out of shape, and repeated repairs had taken place in consequence. The plates over the fires had been taken out and renewed with those of Lowmoor iron, which had every appearance of being of first-rate quality. Also each of the furnace crowns had been lashed to the top of the shell by three vertical stay rods, but the plates persisted in bulging downwards notwithstanding, and came down between and all round the points of support, as will be seen on consulting the accompanying cut, Fig. 1.

Fig. 1. Transverse Section.



Under these circumstances I was requested to examine the boiler and advise the owners as to what had better be done. Immediately on drawing off a little water from the glass water gauge I attributed the injury that had occurred to the furnace crowns to the fine deposit contained in the feed-water, and recommended a scum trough for blowing out from the surface of the water, in order to rid the boiler of this deposit. In answer to inquiries the owners did not think they were admitting any grease to the boiler, and had such confidence in the feed-water, which appeared so clear before it was pumped into the boiler, that I was unable to persuade them to adopt the simple expedient of a surface blow-out apparatus. One cause after another was assigned for the injury, and it was supposed that as the boiler was worked night and day, that the water supply had been allowed to run short at night time, and that the deflection of the plates was due to a series of minor neglects of this character. On one occasion the owners felt sure they had at last detected the source of the mischief. They discovered that the fireman, anxious to get away quickly on the Saturday evening, had started to blow off his boiler before he raked out the fires, in consequence of which the furnace crowns were laid bare with the fires still in, and thus became overheated. In confirmation of this it was stated that it had been frequently observed on setting to work on Monday mornings, that these deflections had been increased, so that the chain of evidence was supposed to be complete. It was soon found, however, that the bulging was too persistent to be accounted for in this way, and the owners, rather than adopt the simple expedient of putting in a scum trough for blowing out the deposit, which there is little doubt would have remedied the evil, resolved on condemning the boiler altogether and on putting in a new one.

The new boiler was of larger dimensions than the old one, the diameter being 7 ft. in the shell instead of 6 ft. 6 in., and 2 ft. $7\frac{1}{2}$ in. in the furnace tubes instead of 1 ft. $10\frac{1}{2}$ in., while the tubes were strengthened at the ring seams of rivets with encircling hoops, which had not been the case in the old boiler. With this new boiler, though not fitted with a surface blow-out apparatus, the same difficulty was not experienced as with the old one, which arose from the fact that the superior size of the new boiler enabled it to do its work more easily than the other, and thus with more gentle firing. As long, however, as the feed is of the same character as it was in the other boiler, the same tendency remains, and it will only be necessary to make the new boiler do as much work for its size as the old one did to lead to the furnace crowns being again disturbed, though doubtless they would derive considerable assistance from the encircling hoops, so that but little bulging of the plates might take place, though leakage would occur at the seams of rivets.

In this case the water was not analyzed, as it was on subsequent occasions, but it may be stated that it left a fine floury deposit of a very similar character to the cases mentioned below, and which were found to consist of from 70 to 80 per cent of carbonate of lime.

No. 2. Another very similar case of the failure of furnace crowns was met with in May, 1866. It occurred in the neighborhood of London, to a Cornish boiler fed with the New River Company's water.

This boiler, I was informed, had failed at the furnace crowns, and repeated repairs been resorted to. These, however, had such little effect that one boiler after another had been laid down, till some three or four boilers had been ruined in the course of three years; while one of the boilers had received a new flue tube. Added to this, experiments had been tried by altering the steam dome, and, altogether, the owner informed me, the affair cost him £700. Disheartened with these repeated failures, he was persuaded to exchange the internally fired boiler for an externally fired one, with a couple of return tubes running through it, which he had just laid down at the time of my visit.

On making an examination of the boiler I found that it contained a good deal of fine floury deposit of a light color, and that the feed-water was heated by the injection of the exhaust steam from the high-pressure engines, so that the grease from them passed through into the boiler. I called the owner's attention at once to these facts, and explained to him that these were the causes of all the trouble he had experienced. He urged by way of objection that prior to the last three years the boiler had worked for a considerable time with the same water, and with the feed heated by the exhaust steam, without giving trouble, and therefore argued that the fault could not be with the water or with the grease discharged from the engines. This objection appeared at first sight difficult to meet, but on inquiry it was found that about three years before then the work became too severe for the engine, when its power had been doubled by the addition of a new cylinder, which gave the boiler more work to do, and necessitated its being more severely fired. This at once made the whole matter plain. The tendency had existed all along, but had not been developed till the fires were pressed.

The following is an analysis of the deposit in question:

Carbonate of lime	73.87
Carbonate of magnesia	4.59
Oxide of iron and alumina	7.07
Organic matter	3.15
Sand silica alumina	11.32
	100.00

N. B.—This was a fine dry powder of a slate color, difficult to wet with water.

It will not escape observation that this floury deposit contained as high an amount of carbonate of lime as 73 per cent, and, simple as it appears, it was through the presence of this fine flour or dust that the four boilers referred to above were ruined, and the expenditure of £700 incurred.*

In the new boiler a good surface blow-out apparatus was adopted, and the boiler was frequently blown out at the bottom as well as from the surface of the water. This proved sufficient to remove the difficulty, though the credit was wrongly given to the change from the internally fired boiler to the externally fired one. Externally fired boilers are effected by this description of feed-water as well as internally fired ones, which will be seen from the next case of inquiry.

No. 3. A third case was met with in June, 1867, at a colliery in the neighborhood of Ruabon, North Wales. In this instance six new plain cylindrical egg-ended externally fired boilers failed within six weeks after they were set to work, giving way at the plates over the fire. These boilers were 5 ft. 6 in. in diameter, 36 ft. long, made of plates three-eights of an inch in thickness, and worked at a pressure of 40 lbs. per square inch. The owners threw the blame of the failure of these boilers on the makers, attributing it to the quality of the plates or workmanship, and consequently a dispute arose, and I was requested to make an examination. On doing this I found that the plates over the fire were of Lowmoor iron and of good quality, and that the fault did not rest with the boilers but with the feed-water, which formed, as in the previous instance, a fine floury deposit, consisting to a great extent of carbonate of lime, while it was heated by the exhaust steam from the engines, and thus charged with grease, in consequence of which, as in the previous cases, the plates over the fire had been overheated and bulged down out of shape, while, in addition, leakage had taken place at the seams of rivets. The manager was unwilling to accept so simple an explanation of the difficulty, though he had previously received a similar opinion from another engineer, and been advised that he must either change the feed-water or give up heating it with the exhaust steam, so as to prevent the introduction of grease to the boilers. Though ridiculing the recommendation, he had nevertheless diverted the exhaust steam from the feed-water, when he found that the result justified the explana-

* From a table compiled by J. Atfield, F. C. S., Demonstrator of Chemistry at St. Bartholomew's Hospital, it appears that the New River Company's water, with which this boiler was fed, contains 19.78 grains of solid matter per gallon. Also that the amount of carbonate of lime is greater than that of any other ingredient, and equals 7.82 grains per gallon.

tion given and remedy proposed. Time showed that overheating did not recur, and the boilers worked on without further trouble.

The following is an analysis of the deposit formed within these boilers, and which, I believe, was taken from them before the arrangement for heating the feed by the exhaust steam was given up, so that at that time grease was admitted:

Carbonate of lime	75.26
Sulphate of lime	10.02
Carbonate of magnesia	8.78
Oxide of iron and alumina	.47
Insoluble matter (sand, &c.)	2.68
Organic matter	2.79
	100.00

N. B.—This sediment was a white powder and smeled of tallow. By digestion with ether, grease was extracted and collected.

The following is another analysis of the deposit taken from these boilers subsequently to the last specimen, and after the practice of heating the feed-water with the exhaust steam had been discontinued, when the boilers were fed with cold water:

Carbonate of lime	84.10
Sulphate of lime	2.25
Carbonate of magnesia	8.73
Oxide of iron and alumina	1.41
Insoluble matter (sand, &c.)	1.98
Organic matter	1.53
	100.00

N. B.—The organic matter did not contain grease.

It will be observed the grease was detected when the feed-water was heated by the exhaust steam, but not after that practice was discontinued.

In addition to the above, further analyses were made at a later date, both of the fine floury deposit and of the scale:

Floury Deposit.

Carbonate of lime	80.00
Sulphate of lime	6.08
Carbonate of magnesia	12.44
Oxide of iron and alumina	.98
Sand, &c	.50
	100.00

Scale.

Carbonate of lime	77.40
Sulphate of lime	9.52
Carbonate of magnesia	10.90
Oxide of iron and alumina	1.22
Sand &c	.96
	100.00

The following is an analysis of the water with which these boilers were fed:

The total solid matter left on evaporating a portion of the water amounted to 45.15 grains per gallon. This consisted of—

	Grains per gallon.
Carbonate of lime	23.75
Sulphate of lime	1.57
Sulphate of soda	4.33
Common salt	2.63
Carbonate of magnesia	5.18
Organic matter and loss	2.69
	40.15

Note.—The carbonates of lime and magnesia are kept in solution by the presence of free carbonic acid. If this is neutralized by the addition of lime, a portion is precipitated. By this means nearly one-half the total matters in solution may be removed. Also in boiling the water, before evaporation commences, a portion is precipitated.

From the above analyses the high proportion of carbonate of lime will be seen in each case:

Analysis No. 1 gave—Carbonate of lime	75.26
No. 2 gave—Carbonate of lime	84.10
No. 3 gave—Carbonate of lime	80.00
Mean result	79.78 per cent.

From this it appears that the mean result was nearly equal to 80 per cent of carbonate of lime contained in the fine floury deposit.

It should be added that at the same colliery there was another range of plain cylindrical externally fired boilers, which had been working for a number of years without failing as the new ones had done. The manager, therefore, pointed to this fact in support of his view that the new boilers were at fault and not the feed-water, since the feed-water appeared to him to be as good in one case as in the other. To settle this question an analysis was made of the water with which the old range of boilers were fed, as well as of the deposit formed within them, in order that a comparison might be instituted, when the following was found to be the result:

Sediment.

Carbonate of lime	22.00
Sulphate of lime	63.78
*Magnesia	14.07
Oxide of iron and alumina	.09
Sand, &c	.06
	100.00

*This would be equivalent to 20.17 carb. magnesia.

Scale.

Carbonate of lime	10.17
Sulphate of lime	72.94
Carbonate of magnesia	15.89
Oxide of iron and alumina	.63
Sand, &c	.37
	100.00

The following is an analysis of the water:

A portion of the water evaporated to dryness, left a residue amounting to 90.3 grains per gallon. This contained—

	Grains per gallon.
Carbonate of lime	.15
Sulphate of lime	16.93
Sulphate of soda	51.55
Common salt	2.93
Carbonate of magnesia	17.11
Magnesia	1.22
Organic matter and loss	.41
Total	90.30

N. B.—As this water is concentrated by evaporation it becomes alkaline.

The addition of lime gives a precipitate amounting to nearly one-third the total matter in solution.

Boiling the water causes no precipitate. There was a deposit of organic matter at the bottom of the jar which contained the water.

The results of the analyses of the feed-waters of the new and old ranges of boilers, as well as of the sediment, will be the more easily compared on reference to the following table:

New Boilers which failed after six weeks' working.

Percentage of carbonate of lime in fine floury deposit	79.78
Grains of carbonate of lime in a gallon of water	23.75

Old Boilers which worked for years.

Percentage of carbonate of lime in fine floury deposit	22.00
Grains of carbonate of lime in a gallon of water	.15

From this table it will be seen how different were the characters of the waters by which the two ranges of boilers were supplied, and how much more carbonate of lime was contained in the one that fed the new boilers, which failed after six weeks' work, than in the one which fed the old boilers that worked on for years, while it corroborates the view that the failure of the new boilers was not due to their material or workmanship, but to the fine floury deposit formed by the feed-water.

No. 4. The fourth case of injury to furnace crowns through the use of a feed-water forming a fine floury deposit, came under my notice in August, 1867, and occurred in the neighborhood of Lancaster, to a range of three Lancashire boilers measuring about 28 ft. in length, 7 ft. in the diameter of the shell, and 2 ft. $7\frac{1}{2}$ in. in that of the furnace tubes, which were strengthened with T iron hoops at each of the ring seams of rivets, while the blowing-off pressure was about 60 lbs. per square inch. In this case, though the feed-water was drawn from a neighboring stream, which was perfectly clear to the eye, these boilers were found to give repeated trouble at the furnace crowns, the plates bulging down, and the ring seams straining and leaking.

The fault had erroneously been attributed to the construction of the boilers, in consequence of which the encircling hoops had been removed and the furnaces renewed with ordinary lap-riveted plates. This alteration was clearly in the wrong direction, and the plates soon bulged, and the seams soon leaked again as badly as ever.

The accompanying cut, Fig. 2, will show the nature of the distortion of the furnace crowns in this case.

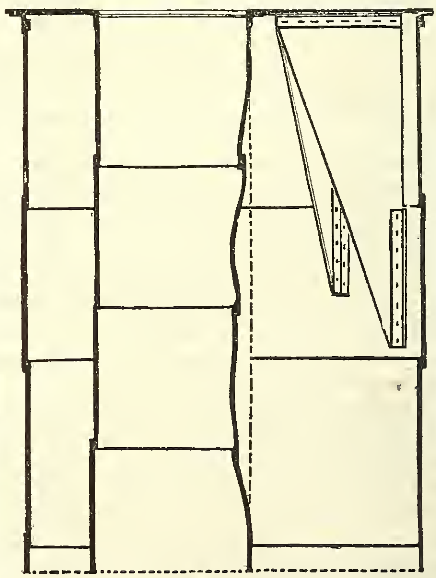


Fig. 2. Longitudinal Section.

At this juncture I was requested to make an examination, and on getting inside one of the boilers, found that it contained a considerable quantity of light floury deposit, very similar to that met with on previous occasions, and already described, while in addition the feed-water was heated by the exhaust steam from the engines, and thus charged with grease. Though a surface blow-out apparatus was fixed to these boilers, it was quite neglected, the connection between the internal collecting trough and the scum tap being broken off, so that it was rendered useless, while the boilers altogether had been very carelessly looked after. These facts were faithfully reported to the manager of the works, coupled with the recommendation that the practice of heating the feed-water by the injection of the exhaust steam should be at once discontinued. But this view of the case by no means proved acceptable. The manager was resolved to have the boilers condemned, and not their treatment, or that of the feed-water. The following analysis, however, of the feed-water and sediment formed by it, shows how similar they were in character to the previous cases referred to:

Sediment.	
Carbonate of lime	84.210
Sulphate of lime	1.447
Carbonate of magnesia	3.991
Iron-peroxide, alumina	1.811
Silica-sand	1.441
Moisture and volatile matter	7.100
	100.000

N. B.—The volatile matter seemed to be of an oleaginous nature, and could not well be estimated.

Water.	Grains, per gallon.
Carbonate of lime	11.228
Sulphate of lime	3.840
Carbonate of magnesia	2.224
Chloride of sodium	2.460
Silica	.550

Total residue, 20.440. Hardness before boiling, 13.5°. Hardness after boiling, 4.5°.

N. B.—The water was clear, slightly acid, and contained but a trace of iron. It has no particular solvent action on iron.

Looking at the above analysis, there can be no question that the character of the feed-water and the introduction of grease, coupled with the practice of allowing the sediment to accumulate in large quantities in the boilers, was the cause of the injury to the furnace crowns, as in the cases previously referred to; while it may be added in confirmation, that after examining these boilers I was informed that one, if not more, of the fusible plugs had been blown out, though covered with water at the time, which is a clear evidence that overheating had taken place. Trying, however, as the feed-water was in this instance, the injury to the furnace crowns would have been materially reduced, and probably avoided altogether, had the apparatus for blowing out from the surface of the water been kept in good order and regularly used.

It may also be stated that at the time of my visit I strongly urged that the boilers should be gently fired, since, under the circumstances, hard firing might bring the furnace crowns down in two hours. I had but just returned to Manchester when the manager wrote me that another of the boilers had failed at the furnace crowns, and the works in consequence were at a standstill. Hard firing is an important element in these cases of injury to furnace crowns with waters containing this fine floury deposit.

No. 5. The fifth case which may be referred to, occurred in Sunderland, to a boiler of the patent double-furnace conical water tube class, and my attention was called to it in January, 1868. This boiler had been found to fail repeatedly at the plates and seams of rivets in the furnaces, in consequence of which frequent repairs had been had recourse to, and, supposing that the injury to the boiler was due to expansion of the parts, and to too much rigidity, a hoop of bridge rail or horse-shoe section had been worked out of Lowmoor iron, and introduced at one of the ring seams of rivets in each of the furnaces, in order to give elasticity. This, however, proved of no avail, the furnaces again gave trouble and bulged inwards, when some strong stays, lashing the furnaces to the shell, were put in, somewhat as in the case of No. 2, and as illustrated in Fig. 1.

At this juncture the owner of the boiler, who was a corresponding member of this Association, saw me with regard to it, and from his sketch of the shape in which the furnaces had given way, the case appeared very similar to those already mentioned, while it turned out on inquiry that the feed-water contained a good deal of carbonate of lime, and that it was heated by the exhaust steam, and thus received the engine sewage. I laid the facts of the previous cases before the owner of the boiler, and on his return he had the feed water changed, when the bulging of the furnace crowns ceased, while, it may be added, that he found on reference that the difficulty with the furnace crowns had commenced with the use of the feed-water in question, so that this afforded a double proof of the cause of the injury, No. 6. The sixth case which may be mentioned, and to which my attention was first drawn about March, 1868, gave as much perplexity as any one of them.

It occurred to an ordinary Lancashire boiler in the neighborhood of Manchester, while the feed-water, which was drawn from a well sunk on the premises, was heated by the exhaust steam from the engine. The boiler measured about 24 ft, in length, 6 ft. 9 in. in the diameter of the shell, and 2 ft. 3 in. in the furnace tubes, while it was worked at a pressure of about 55 lbs. on the square inch. This boiler had been originally constructed for experimental purposes, in consequence of which some steam pipes from 10 in. to 12 in. in diameter were carried through it from one end to the other, which thus served as longitudinal stays to the end plates. As these complicated the boiler they were removed, and gusset stays substituted for them.

Shortly after this the furnace crowns were observed to leak. Whether this had commenced before the removal of the pipe stays just referred to, or not, is difficult to ascertain; at all events, the owner attributed the difficulty with the furnace crowns to the removal of these pipes and the introduction of gussets in their place. This clearly, however, had nothing to do with it, though it was not very apparent what was the real cause. After repeated minor repairs, however, were found useless, the furnace tubes were taken out altogether, the front half of them entirely renewed and strengthened at two of the ring seams of rivets with T iron hoops, while the front end plate of the boiler was also renewed.

The manner in which the repairs were executed appeared on examination to be satisfactory, nevertheless the boiler only worked on a few weeks before leakage again commenced. A consulting engineer was then called in, who gave it as his opinion that the fault was in the workmanship, and that the overlaps had not been well drawn up. The defective seams were therefore again repaired, the old rivets cut out, the holes rimered, and fresh rivets put in.

Just at the time that the boiler was restarted, a number of practical working boiler-makers had a meeting, and discussed the cause of the continued and mysterious leakage that had occurred to this boiler. One of them strongly objected to the encircling hoops, and to these he attributed all the injury, stating that he had a similar boiler under his charge, which was never out of trouble, but always leaking and needing repair; while he considered such a boiler was as good as an annuity to the boiler-mender, and that the man who was charged to keep the one under consideration in order, would never be in want of a job. At length the meeting unanimously resolved that encircling hoops prevented any expansion of the furnaces, and that it was against all the known laws of nature for boilers constructed in this way to keep tight; and further, that within three weeks leakage would set in again, and the works wonld have to be stopped for further repairs. This decision was communicated to the owner of the boiler, and surely enough, within the appointed time the boiler commenced to leak once more. At this the owner was quite disheartened, and regretted that he had not had the boiler entirely renewed rather than repaired.

In a long conversation with the owner at this juncture, it transpired incidentally that when his men first got into the boiler after letting off the water, they found some loose fine dusty deposit within it, when it at once occurred to me that this case might be similar to the others previously recorded in this report. This had not been suspected before, since the furnace crowns were not bulged out of shape, but merely strained at the seams of rivets; while in answer to inquiries it had been stated that the deposit altogether was of a very inconsiderable and trivial character. I therefore explained to the owner my suspicion that all the trouble he had experienced was due to the feed-water, and recommended him at all events to give the boiler a trial with the Manchester town's water, instead of that drawn from the well, a recommendation, it may be added, that had already been made, as a matter of precaution, but had not been thought worthy of adoption. Though he had no faith in the remedy proposed, it was so simple that he consented to try it. The boiler was at once washed out, and the next morning started to work with the town's water. From that day the trouble was over. The boiler worked on satisfactorily for several weeks, and after being slightly caulked so as to remove the effects of the old leakage, it was perfectly sound; and though the T iron hoops, which were decided at the meeting of the boiler makers to be "opposed to all the known laws of nature," had not been removed, the boiler has worked on to this day without giving further trouble, and promises to do so for the next seven years.

The following is an analysis of the sediment, from which it will be seen that carbonate of lime is the predominating ingredient, though it does not form so large a percentage as it did in the previous cases, which it is interesting to notice in connection with the fact that in this boiler the furnace plates were not bulged, but merely strained at the seams of rivets:

Carbonate of lime		38.960
Copper		trace.
Carbonate of lead		1.790
Sesquioxide of iron		5.005
Alumina		4.456
Sulphate of lime		4.490
Carbonate of magnesia		1.216
Magnesia		11.847
Phosphoric acid		trace.
Chlorine		trace.
Sand and silicic acid		17.977
Fat	7.375	10.742
Other organic matter	3.367	
Moisture		2.219
		98.702

The deficiency is partly due to the given percentage of carbonate of lead being too small, and to the traces of alkalies, copper, phosphoric acid and chlorine.

When the boiler continued to work on satisfactorily week after week and month after month, simply by exchanging the well water for the town's water, the owner could not entertain any further doubt on the subject; and on recollecting the changes made in his works from time to time, and remembering how the well had been deepened to increase its supply, he was also able to trace a clear connection between the use of the well water and the leakage of the boiler.

This shortly received a striking corroboration. In the course of the long drought that occurred in the summer of 1868, the supply of the Manchester Waterworks, as all in this locality will remember, began to run short, especially for engine purposes, so that for one afternoon the owner was obliged to fall back on the well water, when, though he tried the experiment for a few hours only, the boiler at once commenced to leak as before, so that he gave up the well water once more, and resolved never to return to it again.

This case, though not so severe as some of the others mentioned, is perhaps the most interesting, from the great perplexity which arose with regard to it, and the conclusive manner in which it was cleared up.

No. 7. The seventh case was met with near Carlisle, in July, 1868. The boilers in this instance, which were of the ordinary Lancashire type, and strengthened at the ring seams of rivets in the furnaces with T iron hoops, drove a condensing engine, and were fed from the hot well. The length of these boilers was about 30 ft., their diameter in the shells 7 ft., and in the furnace tubes 2 ft. 8 in., while the load on the safety-valve was about 50 lbs. per square inch.

These boilers gave way, as in the previous cases, at the furnace crowns, in consequence of which the owners reflected on the makers, and the makers, knowing they had delivered sound work, could only account for the failure by supposing that the boilers had been neglected, and the water supply allowed to run short.

On making an examination, I found that the deposit within the boilers was of a fine floury nature, like that already described in the previous instances, though the quantity was not so great, neither were the furnaces so severely distressed. The following is an analysis:

Carbonate of lime	69.39
Iron (peroxide)	2.17
Alumina	2.03
Sulphate of lime	2.39
Carbonate of magnesia	3.38
Silica and sand	10.73
*Organic matter	7.56
Moisture	2.35
	100.00

From the above analysis, it will be seen that the feed-water was very similar to that met with in the other cases previously referred to, though it will be seen that the percentage of carbonate of lime is scarcely so high, which possibly explains the fact stated above, that the furnace crowns were less distressed than usual.

No. 8. The eighth case that may be referred to, was met with in August, 1868, and occurred to a couple of boilers laid down near the river Mersey, in the neighborhood of Widnes. These boilers were of the ordinary Lancashire type, and were but just new, yet they had failed repeatedly at the ring seams of rivets of the furnace crowns, when the old rivets had been cut out, the holes rimered, and new rivets inserted, but without success.

Under these circumstances, the makers of the boilers called upon me, when, in answer to inquiries, it appeared that the feed-water was heated by the exhaust steam from the

*Containing 2.95 of fatty matter.

donkey engine, and that the deposit was of a light floury character. I at once recommended that the exhaust should be diverted from the feed-water, and on this being done, the difficulty with the furnace crowns was overcome. In about a month afterwards, the boilers were reported as working satisfactorily, although they had never stood for more than forty-eight hours before.

The following is an analysis of the sediment, which, as in the previous cases, shows a predominating proportion of carbonate of lime:

Carbonate of lime and magnesia..	83.33
Sulphate of lime...............	1.17
Alumina and iron..............	4.25
Silica..........................	7.40
Oily matter.....................	.25
Organic matter.................	3.60
	100.00

It may be added that further cases have been met with in the neighborhood of Widnes, and that in December last two other boilers came under my attention, the furnaces of which were bulged out of shape from the same cause as that referred to above.

It is worthy of note that three different cases of injury to furnace crowns from this fine floury deposit have been met with in the neighborhood of the Mersey, and within a few miles of Liverpool.

I have gone into this subject at some length, because it is one not generally understood. It will be seen that the cases of injury referred to were not confined to any peculiar locality, but were met with in the neighborhood of London, Lancaster, Carlisle, Birkenhead, Sunderland, Ruabon, Widnes and Manchester, so that they were widely scattered over the country. It can scarcely be doubted that for the want of understanding this subject, many cases of misapprehension between boiler owners and boiler makers must have occurred, and the blame of leakage at the seams of rivets in the furnaces, attributed to defective workmanship, or overheating, through neglect of the attendants, instead of to the feed-water. It is trusted that the general diffusion of information on this subject will prove of practical value to boiler makers and boiler users, and that the number of examples given will be considered sufficient to establish the fact that both in externally and in internally-fired boilers, the plates over the fire may be overheated and bulged out of shape even when covered with water.

MODERN ARTILLERY AND TACTICS.

From the "Army and Navy Gazette."

There can be few studies so interesting to a military man who loves his profession as the various modifications of tactics that have, from time to time, been forced, as it were, upon the different armies of the civilized world. From the days when the crossbow had to give place to arquebuse, when the latter was superseded by the heavy muskets of the seventeenth century, when, after progressive modifications, the flint-locked Brown Bess became the weapon of the day, when the old smooth-bore percussion reigned supreme for a time, and was put aside for the rifle which, only two or three years ago, was in its turn superseded by the breech-loader—through all the different phases of small arms, as well as large ordnance improvements—the art of war has always, and will for ever, be progressive. The valiant officers, the plucky, all-enduring armies of the Peninsula and of our Indian campaigns in the commencement of this century never dreamt of any improvement upon the cumbersome flint musket, that missed fire at least once in every dozen shots, and if, when it hit the mark aimed at, was supposed to have almost worked a miracle. The arms we use have changed, and tactics have changed with them. The ordnance of to-day is as unlike what we fought the Sikh campaign, or went through the Indian mutiny, or made our way into Sebastopol with, as the smooth-bored flint musket was to the breech loaders now in use. And it must stand to reason that the art of attack and defense of one great body of soldiers against another must be modified in proportion to the arms of the day. At Waterloo it would have been quite possible for cavalry to get over two thousand yards of ground in a charge, and not be subject to danger from more than one volley of the infantry square they attacked. In our time the same troops would be decimated three or four times ere getting home to their work. And so it has been, only in a much greater degree, with artillery. "It seemed," wrote Villani, when speaking of the employment of cannon at the battle of Crecy, "as if God thundered, and that with His thunder there was a great massacre of people and a frightening of horses." And yet, for more than a century after the time that this historian wrote about, the artillery could hardly be called movable. Even under Francis I. of France, the ordnance of the period—mere pop-guns of our own days—followed armies with such difficulty, and so slowly, that the infantry maintained the tactics of the past age, and formed in heavy masses in front of the enemy's guns. Little by little, as the ordnance in use got better and more precise, it became necessary to protect infantry behind walls, or, when in the open field, to deploy battalions so that the artillery fire could not do much damage, even when it penetrated the ranks. Gustavus Adolphus, Condé, Turenne, the Marshal Saxe, the Prince d'Anhalt-Dessau, Frederick the Great, and even our own Malborough, gradually changed the formation of infantry. The real use of this arm only became fully known when the Great Frederick had changed altogether its mode of working. At the battle of Molwitz this great soldier-king learnt what could be done by foot soldiers who fired rapidly and well—that is, well for the days in which he lived. From that time infantry became, throughout Europe, by far the most important arm of the service. It was henceforth seldom massed together in columns. Its lines were extended, and rapidity was introduced into all its movements. With a small army and a very numerous enemy, Frederick was obliged to strike out for himself a new mode of tactics. He avoided as much as possible meeting numbers by numbers, or trying to conquer by material strength, and tried to introduce an improved style of firing, and rapidity of movements, by which an engagement could, when needful, be avoided quite as quickly as it could be brought on. Under him, also, the artillery began to assume the importance it has ever since maintained in modern warfare. The guns were made more movable, and men began to see with wonder something like a system of drill and tactics used when working ordnance to the front, the flank, or the rear. And so on down to the time when, the then, Gen. Bonaparte began to be talked of as a leader who seldom led the way to anything except victory. As the French Republic changed into the Empire, and as the hand of its great chief was against every one, and every one's hand against him, the tactics of the day changed, and became nearer to what they were in our own service within the memory of living men. The bayonet gradually became an arm much used by all infantry. Perhaps no soldiers took to it as kindly as did our own troops; but, still, it effected great changes in the mode of fighting in all armies. In France this weapon became more popular when the campaigns in Algiers worked such an immense change in the army of that country. For close upon forty years France has had work cut out for her troops in the school of war which she founded in Northern Africa. An entirely new type of the French soldier has arisen to be the model man of her service. Individual fighting, looser formations, a manner of achieving an end, no matter how, so that it was achieved, became the rule more than the exception in the army, of which the Zouave is the picked soldier. In our own service, notwithstanding several attempts to introduce the modern French system of almost separate working on the part of each fighting man, we have, with certain modifications, maintained our more compact formations, and our reliance of each soldier upon the whole company or troop to which he belongs, more than upon his own individual exertions. We have made changes certainly, but they have neither been rash nor very considerable. That our system, so far, suits our men much better than greater changes would do, there can be as little doubt, as that we have held our own whenever and wherever we have taken the field. Whether we shall have to make further changes, or whether our infantry movements are rapid enough for the arms with which our enemies, as well as ourselves, will in future carry, is a question which admits of discussion. But there can be little doubt but that by degrees a very considerable modification in some of our tactics must take place. When an average military marksman can hit an enemy at 800 yards seven times out of ten, it becomes that enemy to be more active, either when advancing or retiring, than when a similar feat could only be achieved once in perhaps a dozen shots.

The great difficulty connected with the modifications of modern tactics seems to be that we are yet only in a state of transition as regards firearms. In all that regards both breech-loaders and field-guns, we have advanced far, but shall probably—we might say certainly—advance much further. Even, however, if progress has reached its limits in the perfection of arms of precision, it becomes a matter of wonder how far future cavalry can ever be used against unbroken infantry, when armed with the breech-loaders now in use, and taught to fire as the ordinary average of regiments are. There is a point beyond which courage is mere rashness, and pluck on the part of the commander becomes a wanton waste of life. Would not such be the judgment passed upon any cavalry leader who would launch his regiment or brigade against an infantry square armed even as our own and other European armies are at the present day? Against infantry broken or in retreat, against the same arm when thrown into confusion by some blunder on the part of their commander, against the cavalry of the enemy, or against artillery when not unlimbered, dragoons must ever prove of the utmost service, and no army in the field could do without them. So it is when feeling for an enemy, when pushing to the front, and anxious to bring on an engagement, the cavalry arm must ever be present to do that which it alone can effect properly. But unless some change, of which as yet we know nothing, takes place in the firearms of the world, we shall, probably, never again hear of cavalry being used to charge infantry squares as in old time.

Again, it is an open question how, with the present improvements in artillery, either infantry or cavalry can ever be used in the open field to silence a battery of guns. At the present day the artilleryman, although he cannot load as quickly, fires with almost as great precision as the infantry soldier. In the advance of an infantry brigade against a battery, unless circumstances were exceptional and much in favor of the former arm, there would be no formation left by the time they reached their destination. This, as a matter of course, can be rectified very much by rapidity of movement on the part of the infantry soldier, and in this change, as we imagine, will be found one of the chief alterations of modern tactics. Much greater quickness in advancing; the "double" taking the place of our present quick time; and a certain reckless dash, which will tend greatly to abolish steady formations, will probably supersede many of the movements now in use. But the chief change will most likely be a rule by which no arm of the service will ever, or very seldom, be employed alone. Brigades will probably not be composed of cavalry nor of infantry alone, but each one, and perhaps, indeed, each regiment, have a certain force of cavalry and infantry attached to it. In the state of transition which we find ourselves to be, and in which every army in Europe must find themselves to be, these speculations on future tactics must be more or less vague. But it can hardly be said that they are improbable, far less impossible. As we advance in the excellence of firearms and of ordnance, it seems likely that each branch of the service will depend more and more on one another, and that the smallest commands will become what divisions of the army have been hitherto—a mixture of cavalry, artillery and infantry, and that every officer who aspires to command even a regiment must be able to know how to command and when to use other arms of the service as well as that to which he himself belongs. At any rate, as far as it is possible to see, this appears the only possible solution of what is the military mystery of the future. But for the changes to become visible, or for any definite rules upon the subject to be practicable, we must wait for the experiences of the next European war.

THE ESTIMATES OF CONSULTING ENGINEERS.

From "The Engineer."

Possibly in one case out of fifty, probably not in one instance out of five hundred, does the actual cost of a heavy job coincide with the estimate previously prepared by the engineer. This proposition is so well understood, that it is accepted as an axiom, that the total cost of a bridge, or an embankment, or a mill, or a factory, must be in excess of the estimate; and as a kind of precautionary measure intended to defend the engineer from the charge of incompetency which may be brought against him, and the capitalist from the consequences of not properly counting the cost before he begins to build, a something, known as "a margin for contingencies," is always added to every estimate, and forms, indeed, an integral part of it. This margin, however, seldom or never suffices; for, as a rule, the outlay always exceeds not only the calculated cost, but the calculated cost and the margin as well. If the excess be moderate, no very serious consequences may ensue; but it must not be forgotten that the excess has not unfrequently been so large as to entail the total ruin of the capitalist or capitalists; or at least to reduce the profits which he or they expected to realize to a nominal return. An estimate right within 20 per cent of the actual cost is, however, regarded as a very good estimate, and one reflecting much credit on the engineer and all concerned. Yet this 20 per cent is to our minds sufficiently unsatisfactory, and bears small testimony to the value of existing systems—or want of systems—of estimating the cost of work. It ought to be, and no doubt is, possible to ascertain beforehand with much accuracy, how much money will be spent in carrying out any undertaking to a successful termination. This is proved by the fact that estimates, perhaps accidentally, do now and then agree very closely with the actual expenditure; and it is worth while, we think, to inquire why such an agreement is exceptional instead of being the rule.

The reasons why estimates and expenditure so seldom coincide, are two in number. In the first place, the engineer does not accurately know how much work has to be done; in the second place, he does not know how much the doing will cost. As regards the first, it is possible that the engineer may not be at all to blame. The preparation of a complete design for a complicated structure, such, for example, as a cotton mill, is all but impossible. When the drawings come to be made, a host of small things are certain to be left out, simply because they cannot be put in to any reasonable scale on paper; they are to be supplied afterwards. It is known in a kind of way that they will ultimately be needed, but no one thinks of wasting time in ascertaining what they will really cost, and of what they will consist. Almost from the first moment they are put out of sight, and to nothing more than to such trifles as these will the proverb "out of sight out of mind" apply. The so-called trifles, however, make themselves disagreeably prominent before the work is completed. They must be supplied and paid for, and they not unfrequently constitute an ominous feature in the bill. We shall not pretend to define in what trifles of this kind consist. Every engineer who has prepared an estimate for work differing from anything he has estimated for and carried out before, will be likely to class trifles, using the word in our sense, under a different head. No engineer will deny their existence, their costliness, or the influence which they exert on estimates, and this much admitted, our proposition is granted.

Under certain circumstances, however, we find the engineer very much to blame, because he totally overlooks the necessity which exists for the construction of essentials, or relegates important features to the region of real trifles. The result of such negligence, or errors of judgment, may be disastrous. We recollect one case in which a factory was put up, and boiler and engines put down at a cost of about £10,000. It was known that no water from river or stream was available. A shallow well was therefore sunk, and from this water sufficient for mortar, &c., was obtained during the progress of the works. The insignificant cost of this well was included in the estimate. By the time the factory was completed, however, it was discovered that not nearly enough could be had from it for the purposes of manufacture. A very large further outlay—nearly £1,000—was incurred in sinking the well deeper, without leading to any satisfactory result; and, finally, rather than abandon the factory altogether, £2,000 more were spent in laying a main and opening a cutting from a river at a considerable distance. Here the original estimate was increased nearly 50 per cent by a single mistake. Such cases are, of course, very exceptional; but it is not at all exceptional to find estimates based on the first cost of machines delivered at the works, not one farthing being added for erecting them; the value of the bricks required based on their price in the field, the trifling question of carriage being totally forgotten, and such like. Such mistakes as these will cause actual outlay to exceed estimated cost with great certainty, and it is the easiest thing in the world to be guilty of them. None, indeed, but those who have had to prepare estimates for large undertakings, can tell how much trouble, and what unceasing watchfulness is required at every step to avoid error.

Even if we suppose the engineer to have ascertained with the utmost accuracy everything that can possibly be required, from the steam engine to the time-taker's clock, it does not follow that his estimate must be right: the second class of error to which we have alluded to may come into play. It is one thing to know what you want to buy, quite another to know what it will cost. An engineer may determine with strict accuracy how many yards of earth must be taken out to prepare an engine foundation, but his estimate of the cost of taking it out may be altogether wrong, for it is not the quantity of earth to be removed, but the whole cost of removal, that affects the precision of the estimate. In the first place, he may not have taken the trouble to ascertain the cost of labor, or the nature of the soil; in the second, water may come in on him, and defeat all his calculations. In estimating for machinery, the engineer is peculiarly apt to fall into error. He sets down the cost of engines and gearing at so much, and on going into the market finds that no manufacturing engineer will touch them at the price. The reason is simply that the manufacturers, knowing that estimates generally err on the wrong side, put on a "margin for contingencies," on which the would-be purchaser has not calculated at all. He puts down £2,000, we will say, for engines and boilers. He has, perhaps, worked out the cost of these very carefully on paper. The maker does the same thing, and comes, perhaps, to nearly the same result, to which he immediately adds 50 per cent, not only for profit, but as margin, and to cover the chance of loss. Both parties are right in their own way, but our engineer's estimate is all wrong. Nor is this the only difficulty which those who prepare estimates have to contend against. It is sometimes almost impossible to say what work ought to cost, prices vary so much in different districts, and among different makers. We may state a case in point which recently came under our own notice: An engineer putting up large works, required some heavy castings. Before preparing his estimates, he wrote to some of the leading firms in the country asking the prices at which they would execute the work. Before a week was over he found that he could have his castings at any price, from £12 to £5 7s. 6d. per ton, and, in any case, sufficiently good for his purpose. Some of our readers may say that this gentleman adopted the proper plan, and that estimates based on actual tenders in this way, could not be far wrong. This supposition, however, is true only within certain limits. We may cite a case in point which came under our own notice a few years ago. An engineer had occasion to order some very heavy gearing. He got two or three tenders for the castings, and he accepted the lowest tender. A moderate quantity of wrought iron work, in the shape of plummer block bolts and nuts, wheel boss hoops, &c., was also required. This he did not think it worth while to ask a price for, regarding it as a trifle. The work was delivered, and so was the bill; on examining it the engineer discovered that so much had been charged for the wrought iron, that instead of obtaining the gearing as a whole, at the cheapest, he had paid at the dearest rate. The other tendering parties would have charged a little more for the castings and a great deal less for the wrought iron, that was all.

We have said enough, we think, to show that consulting engineers are called upon to discharge a difficult duty in the preparation of estimates; a duty, we may add, often so badly paid for that he is sorely tempted to slur over his work and add a good margin for contingencies to cover his short comings. It is not to negligence, however, that we are inclined to ascribe the thoroughly unsatisfactory state in which the practice of estimating now is, but rather to incapacity. There is no good treatise on the subject, although there are plenty of "price books" containing forms of tender and specifications. The art of estimating forms no part of the present course of engineering instruction, either in the office or the college. When a young man can take out quantities and prepare an estimate at the rate of so many rods of brick work so much, one steam engine fitted complete so much, &c., &c., he is considered to have his education finished in this direction, as far as the office or the college is concerned, while in point of fact he is no more competent then to form an accurate estimate than if he had never been taught engineering at all. Those instructors of youth who doubt this statement, will do well to test its accuracy thus. Let them procure the bills furnished to and paid by any large manufacturer or ironmaster for the erection of any given premises or machinery. Then let them lay down the prescribed conditions to three or four of the most advanced pupils they have got, ask them to send in estimates elaborated from their own brains, aided by such treatises as they can find on the subject, and compare these estimates with the actual bills paid. They will see that our statement, that no pupils are taught anything practically about estimating, is confirmed with startling force. Is it not just possible that the test we have indicated might be made a valuable feature in the courses of engineering colleges, and the method of instruction adopted by private teachers? We think so; and we further think that there would not be the slightest difficulty in introducing it. A little less mathematics, and a little more instruction as to what things really cost, would be a change for the better in the young engineer of the period.

BAD AXLES.—Certain railroad companies are putting in passenger axles which they know to be made *at one piling, from old rails only.* Such trifling with life is frightful.

STEAM GAUGES.—Very few years have elapsed since Mr. Daniel Kinnear Clark called steam gauges on locomotives luxuries, not necessities. At this moment we believe there is not a locomotive in Great Britain working a railway carrying passengers which is not fitted with a steam gauge. The truth is that when Mr. Clark wrote, the world, with the exception of a select few, knew only of the cumbrous mercurial gauge, or the yet more imperfect manometer. The Bourdon gauge had only been talked about by users of steam power in general, and it was quite natural that Mr. Clark, in common with the great body of his professional brethren, should regard all known gauges likely to suit a locomotive as mechanical quiddities—things of the border land which lies between true mechanical science and *quasi* mechanical humbug, and reject them accordingly. The manufacture of gauges has, however, become a great trade, and now not only every locomotive engine, but almost every boiler and every portable engine in the kingdom is fitted with one. The steam gauge has asserted itself, so to speak, and by its obtrusiveness it has forced itself into that position where criticism begins. Where this last may end, only the makers of steam gauges can say.

A steam pressure gauge can only be used for three purposes. The first is to tell accurately the pressure in a steam boiler at any moment when the water is hotter than 212 deg.; the second is to tell variations in the steam pressure from time to time; and the third is to bring in money to the makers. We regret to say that the last point is more studied than the others; indeed, so much studied that the value of the modern mercantile steam gauge as an index of the pressure within a boiler at any moment is very small indeed. There is nothing like facts to prove assertions; and as we plainly repeat that the modern steam gauge of commerce is a very worthless instrument, it is right that we should adduce facts in proof of our statement; and as these facts tend to show what maker deals best with his customers, and who serves them worst, our statements should prove all the more valuable. It is well known, or should be well known, that under ordinary conditions the Royal Agricultural Society will not permit a greater pressure of steam to be used within the limits of their show-yards than 50 lbs. per square inch. Every exhibitor intending to get up steam must, therefore, submit the gauge with which his engine is fitted to the Society's engineers, Messrs. Easton & Amos, who test the gauges and return them with a certificate that the boiler may be worked at a pressure of so many pounds by its own gauge, which is equivalent to 50 lbs. per square inch. We have taken the trouble to examine nearly every certificate granted by Mr. Amos this year at Manchester, and to compare each certificate with the gauge. The following table shows the result:

No. in catalogue.	MAKER OF GAUGE.	Pressure equivalent to 50 lbs.
2	Schaeffer & Budenberg	47
236	do	50
237	do	48
980	do	55
6086	do	51
6092	do	49
6094	do	46
6121	do	49
6122	do	54
6125	do	52
6127	do	56
6129	do	48
6161	do	42
6297	do	50
6412	Schaeffer Bourdon	
6513	do	48
6414	do	48
6415	do	48
6417	do	48
6418	do	48
6317	do	53
6337	Schaeffer & Budenberg	48
6514	do	48
6616	do	46
6643	do	52
62	Salter Bourdon	48
2122	do	47
609	Dubois Bourdon	52
6307	do	47
5670	do	50
7510	do	45
819	do	46
823	do	47
5668	do	50
6316	Baines & Tait	50
607	do	52
635	do	50
6557	Smith, Nottingham	45
6534	do	45
6501	do	44
6187	Bourdon	50
2132	E. Bourdon	52
6160	Dewit	52
6136	do	50
6138	do	49
6135	do	49
6085	do	56
6494	do	52
6326	Bailey Bourdon	54
5301	Storey Bourdon	55
6458	Hayward, Tyler & Co	51
6488	do	51
7497	No name "Improved Patent"	50

Here we have 52 gauges by recognized makers, and out of the whole number only 9, or less than 18 per cent, are correct. This is a fact which, we fancy, will startle our readers, and we trust open the eyes both of guage makers and guage buyers to what they are selling and making.

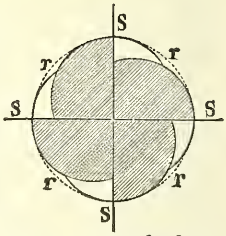
It may, of course, be urged that the gauge used by Mr. Amos in testing those of the exhibitors is not accurate. But even if this were true—and it is not—there would still remain an immense discrepancy between the tested gauges themselves. No want of accuracy in the standard gauges can affect this part of the question. If we suppose, for example, the standard gauge to be 5 lbs. too high, denoting 50 lbs. when there was only 45 lbs., then we should have Smith right; but, on the other hand, where will Schaeffer be? One of his gauges, under such conditions, would be 11 lbs. wrong, and none of the others will be less than 3 lbs. wrong. When it is borne in mind that steam gauges, properly used and properly fitted, play a very important part in the prevention of explosions, all this want of accuracy comes out in a very bad light. Nor do the figures we have given show the worst. Gauges were brought up to Mr. Amos to be tested which were 30 lbs. wrong, and which he, very properly, would not allow to be used at all. Let us hope that such imperfections are the result of ignorance or carelessness rather than of a determination to ignore every other condition save economy. Twelve months will elapse before the gauges used by the agricultural engineers of Great Britain are again publicly tested. Is it too much to expect that we shall have a different record to place next year before our readers?—*Engineer.*

IMPROVED SHAPE OF SCREW-TAPS.

By Prof. O. Beylich.

Condensed and translated from Polyt. Centralblatt.

The "Propagation Industrielle" contains an interesting article on a method of making screw-taps of a new and improved shape, as practiced in the large machine-shop at Graffenstaden. The screw-taps are there turned and cut in a turning-lathe provided with a peculiar mechanism, the effect of which is, that the pieces produced by turning and by the cutting of the thread are not circular in section, but of a shape more favorable to a successful working of the tap when finished. It is generally acknowledged that the screw-taps as made heretofore, conform but imperfectly to what must be expected from a good cutting-tool. The action of an ordinary tap does not produce regular chips; it does not leave room enough for them, nor allow the oil easy access to the working-edges. Thus they produce an unnecessary amount of friction, and become rapidly blunt and worn. Some improvements have been made in this respect. But the cylindrical or conical shape of the nucleus of the tap has been retained. No tap, however, having a nucleus of a circular section, can ever work as advantageously as any other good cutting tool; for it does not suffice that the edge be sharp. The tool, besides, ought not to touch the surface of the screw to be cut, but just with its edge; and the cutting edge ought to be free at the back, and must therefore have a tooth-like shape. To make the action of the tap as perfect as possible, not only the edge formed by the intersection of the upper and lower surfaces of the triangular thread must be eccentric, but also both surfaces of the thread must recede eccentrically from their respective cutting edges. This is effected by the method of cutting taps as adopted at Graffenstaden.



The annexed engraving may give an idea how this is done. The fine dotted outline is circular, and indicates the section of a piece of steel turned off in the ordinary way. The above-mentioned peculiar mechanism, however attached to the turning-lathe at Graffenstaden, does not turn the piece circular, but in a shape indicated by the full drawn outline of the annexed figure, so that the piece obtains a wavy surface. The cutting of the thread is afterwards done in the same manner and with the same mechanism. Thus a screw of a wavy section is produced with alternating swells (*s*), and recesses (*r*), each of which extends over the whole length of the piece. The number of swells corresponds to the number of teeth intended to be given to the tap. Our engraving shows four of them. To finish the tap it is only necessary to cut out one half of each swell by a planing or a milling machine, to a depth corresponding to the required length of the teeth. Thus taps are obtained of a section about as indicated by the hatched surface in the engraving. The planes of the cutting-faces pass through the axis of the tap. S.

PATENTS AND PATENT LAWS.

By W. Bridges Adams.

From "The Society of Arts Journal."

The word "monopoly" is one of exceeding ill odor with the great mass of the community, and to affix such a name to patents is considered a very clever move on the part of their opponents. It catches the public ear, and the public is very apt to take things for granted, that appear to conform to its interests. What is a monopoly? A privilege conferred upon special individuals, for their own advantage, to the disadvantage of the community. At first sight, numerous private rights appear to be monopolies—land, mines, forests, rivers, the raw material of the world, which are the property of the whole human race, as tenants in common; and for individuals to possess and own them as private property, is simply a concession granted, because they will produce a generally greater fruit by the process of individual enclosure, than by a general scramble. The conversion of the raw material into useful forms, by the operation of the human brain and human hands, creates another kind of property, giving the raw material far greater value by mental and physical labor, labor which would not be given unless the owners could reap some of the fruits of it by an enclosure of the results of their own brains or hands as their own property. Origination of new and useful ideas and forms, producing something better and more useful than has been produced before, is the most valuable kind of labor, and, therefore, the world, in proportion as it becomes civilized, gives exclusive property, for a longer or shorter time, to the producers of the ideas, and goes still further in giving hereditary rights to long-continued industry.

Language is common property, but the author of a book, putting language into new forms, in combination with ideas, is endowed with what is called "copyright" for a term of years, a monopoly, in short, for the reason that, without that monopoly, the books would not be produced, or only a very few books would be produced by a few wealthy and powerful persons; and the very title of the book is also a monopoly. Another person produces a picture which has a high value, and the right to reproduce that picture by engravings or photographs, or other means, is reserved to him. Another produces new combinations of musical sound, and the multiplication of copies of this music is as much his own property as the original. Another produces a piece of sculpture, with the same results. Another produces a new design for furniture, or patterns for dress, or other manufacture, and that is as much his own, with the exclusive right to sell it entire or in copies, as though it were the corn and cattle of the farmer, or the fruit of the orchard owner, or the vegetables of the market gardener.

This monopoly goes still further. The style and title of a firm is private property; and, as if to guard against the contingency of the same Christian and surname in combination being used for competition by a namesake, trade-marks were invented to insure the monopoly, and every possible means are resorted to to prevent a trader's individuality from being trenched on by his neighbors. Yet more: a proprietor of a newspaper, with no individuality, and who purchases all his wares ready made from other persons, has the exclusive right to a particular word or combination of words out of a dictionary, which, if he be the first to assume, no one can appropriate till he chooses to abandon his right.

Throughout all these things it is the right of property which the law jealously guards, mental or other. But for this law, a large mass of mankind would disguise themselves in their neigbors' likeness, to reap the profits accruing from their neighbors' reputation.

What are called patents, are mental originations, multiplied in matter, and the law professes to confer on the originator the sole right to use and sell them to the public for the course of fourteen years. Some of these originations are very popular, and an enormous trade grows up, from which large profits accrue, and it is very commonly an article not of real importance to the welfare of the community that makes the largest profits; but whatever it may be, trade rivalry is excited, and any means are resorted to for evading the patent, without payment to the inventor. Everything previously known in the trade is at the disposal of the rivals; but the Naboth's vineyard they covet is the new thing which the public prefer, either for its superiority or its cheapness, and which has been the production of the inventor's brain. So they set to work to defame him, to deny his originality, to call him a monopolist, to decry his invention, to try and invade it by inferior methods, and, finally, to take advantage of inefficient laws, to plunge him into costly trials that may ruin him, and put the invention out of use, if they cannot appropriate it to themselves without paying anything for the cost of its production.

A few years back, an attempt was made to decry and abolish patents at the meeting of the British Association, and now once more an attempt is making to obtain a huge monopoly, under pretext of abolishing another —not a monopoly as of old in the case of the corn-laws, for the benefit of landlords or landowners, but for the supposed benefit of trade-lords and capitalists generally. Large manufacturers, material converters, and similar people, desire to get the use of brains without paying for them, or to keep things as they are. It is not a case of patentees against the community, as their opponents endeavor to make out, but a case for the community itself, as interested in progress, against wealthy traders who would keep down all progress, if by so doing they could keep up their own profits. It is the case of the community, in behalf of the active brains that work for them with mental capital, and without material capital, against the dull and inert brains, with material capital in masses, which at present, stimulated into competition by the restless brains around them, lead an uneasy life, and would fain become the slaveholders of the active brains, and prescribe limits to their labors under their own control, and for their own imaginary benefit. It is an attempt to create an hereditary trade aristocracy, by taking away the fulcrum through which clear brains rise into the possession of material capital, and their owners elbow the inert rich from their seats. And, not uncommonly, it is those who have grown rich upon patents who are the most strenuous opponents of other men's patents.

The common ground of opposition is that patents impede progress. If they did, that would be sufficient reason for their abolition. But assertion is not demonstration. It is asserted that the patent is a monopoly which no one but the owner can use. Quite true; but so is land a monopoly which no one but the owner can use, the difference being that the patent is a monopoly for fourteen years, and the land forever. The patent is a fourteen years' monopoly of individual brain-work, the land monopoly is that of the material works of the Creator. If the land were the property of the State, the rentals would belong to the general community as a tax fund, and the community gives it to individuals on the supposition that they will manage it better for the general benefit of the community than the State could, the rental being the payment for their trouble. The patent is a limited property, the land is an unlimited property, both conferred by the community, and capable of resumption, if demonstrated to be mischievous to the community.

The brain-worker can only, in the case of patents, operate by the agency of matter, the property of the landlord, who exacts a large share of the brain-work in return for the use of the matter. But the brain-working patentee has no monopoly. He is exposed to the competition of all others using the landlord's matter, or the materials of the Creator, save in the patentee's particular mode. And no sooner has he achieved a success, than other inventors are immediately at work to eclipse him, to the benefit and advantage of the public; and it is notorious that, even in the case of a successful invention not superseded by another improvement, commonly half the fourteen years' term expires before an invention is brought even into limited use.

The large manufacturer has his choice of patents by competition amongst brains, saying nothing of the stored-up records of lapsed patents at the Patent Office, which he rarely has recourse to, save to compete with, and defeat, something new, which a rival manufacturer has produced under a patent, and turned to profit. It is well known that few manufacturers will embark in new things without the protection of a patent, for the reason that money must be expended experimentally, and that rivals lie in ambush to reap the profits in competition, without outlay, and consequently can undersell the originator, and for this reason the records of lapsed patents in the Patent Office are not resorted to, but remain dead letters.

It has been sought to make a distinction between copy-right and patent-right. There is none; they are alike, in their integrity, original emanations of the human mind, and we may be quite sure that the abolition of patents would soon be followed by the abolition of copyright in books or works of art. Copyright in designs is copyright in a representation. Patent-right is copyright in form, and utility, and methods of production; whether brain imagination be multiplied in printed books, or in music, or in engraving, or artistry, or design, or theatrical exhibitions or shows, or stamped on matter under what are called patents, it is the same pro cess of expressing mind in matter as an origination; and as the originators are comparatively few in number, it is desirable to cultivate them, and give them enclosures of mental domains wherein to have free scope for the exercise of their various arts, for precisely the same reasons that the enclosures and private ownership of land—a common property—is granted to the producers of food, and for other purposes.

It is simply the system of bad laws to which all the evils of patents are traceable. There was a time when, amongst the manufacturers of printed fabrics, all new designs were kept secret as far as possible till the moment of issue, and all were busy bribing, or trying to bribe, their neighbors' designers. The Act for Copyright in Designs, abolished this system of piracy, and with it the secrecy. Were patents abolished, one of the results would be a return to secrecy in all small things, a closing of manufactories against inspection, and a general dearth of information to mechanical periodicals, while improvements, involving a large outlay of capital, would cease to be made, unless perchance in government establishments.

If the spread of knowledge be a national advantage, the inducement to secrecy by the abolition of the patent—*open*—would be a serious evil.

Amongst the reasons alleged for the abolition of patents, one is, that the patentees gain no advantage—being ruined by opposition and lawsuits, in case of the invention being successful.

This is the greatest farce of all, as if land property would be safer than brain property, were it protected by as bad and inefficient laws as patents are subjected to, and as if there were any difficulty in making as efficient laws for patents as for books and designs, were only influential men interested in bringing them to pass, and lawyers not interested against them.

Another allegation is, that the great mass of modern patents are useless. If they are useless they need not be coveted. If impedimental, they certainly must supply something useful. But it is again alleged that they are frivolous. But is not trade itself widely frivolous? Yet what merchant is there who despises anything frivolous, provided only large profit be mixed up with it? What is more frivolous than the majority of theatrical farces, yet what is there more carefully guarded against piracy? But, say the objectors, patents are granted for things not new, and merely serve as an excuse for lawsuits. That simply means that the law and practice have not yet been fitly established. Some say that patents are becoming so numerous that they cannot keep count of them, and so unwittingly infringe them. This is not logical. The patentee might as well object, "The great manufacturers make so many new things without giving me notice, that I cannot keep count as to my originality." This complaint on the part of manufacturers only proves that they manage their business badly. It is surely part of the business of a great manufacturer to know of everything produced in his special art, and, therefore, he should keep a book of patents, as regularly as his price list, with a managing clerk to it. He can, at small cost, have all the specifications in his trade supplied to him as fast as they come out, and he can index them, and mark out all the real novelties and utilities, and put them to use by agreement with the owner. It is said that every British subject is bound to know all the laws, or take the consequence of breaking them, and certainly a British manufacturer is bound to know all the patents in his trade as part of his business.

All existing knowledge and manufacturing experience up to the present time, is the joint property of the whole nation, less certain things protected by patents expiring in fourteen years. But these patents are the "Naboth's vineyard," coveted by the lords of trade.

But they may fairly say that amongst the numerous patents there are many fictitious ones, involving lawsuits, and thus deterring them from the use of what is really common stock. That is to say, the patent laws are bad laws, so bad, that were all laws equally bad, the nation would be in a condition of anarchy. To abolish the patents, instead of to reform the law, would be a precedent upon which we might abolish all laws.

Let us begin at the beginning. Patents are virtually granted for something new and useful, thereby to teach the public, and the reward for such teaching is a fourteen years' exclusive right. What, then, is "novelty?" There is nothing new under the sun, absolutely. The patent is really granted for something new to the existing generation, as an inducement for a skilled man to bring it into use. The title should, therefore, be put on a similar footing to that of land. A piece of unowned land, unclaimed for thirty years, becomes the property of whoever may occupy it, and forever. Therefore, supposing patents to be in the interest of progress, absence of public use for thirty years should constitute a claim to anything useful as a novelty for fourteen years, or such time as might be deemed equitable.

Everybody of legal age should be competent to apply for and obtain a patent, but as any preliminary examination and refusal might involve an accusation of nepotism or a contingency of error, not afterwards to be amended, it is desirable that protection should be granted, if desired by the applicant, after pointing out to him the defects; and that the specification, after completion, should be put on open, not secret trial, by a competent judge, in the presence of the patentee, and the original fees should cover this cost. It is not desirable that a model should be put in at first, as involving the employment of workmen and the risk of discovery before protection is granted; and models being expensive, it is not fair to encumber the patentee with costs.

The affirmation of the patent by the court, should preclude all further litigation as to title and right, the court itself taking the initiative, or acting at the instance of a complainant.

Pecuniary damages should be dealt with by a magistrate, as in the case of copyrights, or by the ordinary courts of law.

Fictitious patents abolished by the court, would cease to be a nuisance in the hands of sharking pretenders. There are very few patents requiring deep thought to apprehend them when produced, or any length of time, when legal quibbling is abolished.

An inventor should not be bound to license other persons, for the reason that they might be rivals, only taking a license in order to damage his invention in public reputation. If an unreasonable man, he would damage himself by limiting the use. If a manufacturer, he might be interested in selling at the lowest price without royalty profit, and thus as a small capitalist he might compete with great capitalists, by securing the trade in a better article.

If the invention were a small item in a large machine, and the inventor required an unreasonable royalty, that would simply be a stimulus to other inventors to make other improvements, and this would be clearly in the interest of the public.

In cases where the subject of a patent has been in private use previous to the specification, unknown to the patentee, it would become a question for the court to decide as to whether the public had been kept out of the knowledge furnished by the patentee, and if so, the patent should be confirmed, subject to the use of the first user, but without giving to him the right to license earned by the patentee by his publication.

No excuse of ignorance of a patent should be admitted as a plea or mitigation of infringement, because, with the full means of obtaining the records of the Patent Office, the ignorance must arise either from willfulness or negligence.

Patents are the Magna Charta of the material progress of a nation, by the agency of the rich brains of men, poor in practical capital, who can mould matter to man's uses after new and useful fashions, just as copyright is the Magna Charta of the nation's progress by the agency of men of rich brains, who can mould language to men's uses after new and useful fashions. When laws shall be made to take away this charter, and throw brains into common stock, one of the sources of England's eminence, her true equality, will have departed from us, and the trade lords will find that their vitality has departed with it. They will compete with each other with increasing competition and lowering profits, till their trade becomes as wild land, which no one cares to cultivate. They will then find that the fourteen years mental enclosure, which induces men of thought to bring forth new things, is also one of the processes essential to profit, and that by abolishing it they "kill the goose which lays the golden eggs."

Trade-marks are the legitimate arms and quarterings of a trade aristocracy, guarantees of honesty in execution, and which become valueless as a manufacture becomes debased. They are monopolies in one sense, as they enable the owners to keep to themselves a large trade, so long as they keep up their character, and the law now jealously deals with their infringers. The patent is also a trade-mark, exclusive for fourteen years, enabling the owner to establish a reputation for originality and improvement, and to keep his reputation when thrown into competition with rivals. And with patents confined to the owners of manufactories, that would simply be establishing a caste of veritable monopolists.

The question has been dealt with thus far simply in the interest of the public, regarding the inventor merely as a part of the public. But the true inventors are more than this—they are a select body of students, who foresee those things that the manufacturing men of routine pass by blindfolded, and thus stir them up to action; and the public is deeply interested in caring for these men, and guarding their interests as their own. From the trade point of view, the mere manufacturer only looks to the profit per-centage attainable by the raw material into wrought, and would work up the whole raw material of the land, and afterwards throw it into the sea, if realizing the percentage thereby. It is this class of men that deteriorates our national manufactures in money competition, that makes rails as brittle as cast-iron, and delights in shoddy; that has no perception of, or care for progress, but only for money.

It is not thus that the greatness of England has grown; nor is it of the highest importance that inventors should reap enormous fortunes, albeit trifling in proportion to the gain to the general community; but it is desirable that they should be in the unanxious position requisite for the most advantageous pursuit of their studies and experiments, as a result of their own labors.

The nation in which all classes of its people can rise in succession, according to their faculties and cultivation, from the lowest position to the highest, must ever be more powerful than a nation of castes, and a nation without laws efficiently protecting mental as well as physical property, must degenerate into a land of castes—or robbers.

There is yet another allegation on the part of opponents of patents. Having to pay a royalty in England, other nations paying no royalty can undersell them. It is scarcely so, for other nations are as desirous of having patents as English people are. Of the two republics, America and Switzerland, the former abounds with patents, the latter has none. The reason is, that in the former case they are a function of the Federal government, in the latter of every separate canton, rendering patents a practical impossibility. But citizens of Switzerland expatriate themselves, and get patents here and elsewhere, and it is probable that the patent branch of legislation will be transferred to the Federal government, and Switzerland will cease to be an exception to other civilized States.

With a climate and condition like that of England, where workmen live longer and do more days' work in every year than in most other countries, it is impossible that she should be undersold in her indigenious manufactures, so long as her materials shall endure. Capital embarked in the growth and training of a workman, is profitable in proportion to the length of his working life, and the faithful and honest work produced.

The assumption that every patentee only forestalls a number of other persons, who would have discovered or planned the same thing, may or may not be true, but this does not concern the public. What the public want is individuals who will work, and teach in the best mode he can, something new and useful; and daily experience tells us that such individuals cannot be obtained save on the condition of thereby obtaining a specific sphere of action involving their own benefit as well as that of the public. Let any one try if, by simply publishing a new and useful thing, he can get it taken up unless he can offer an exclusive right with it. Neither is there any probability in the assumption that all the principles of action have been discovered, and that the details are in every one's hands. The tree of universal knowledge is yet far from having been plucked, and it is to be desired that the men of science, as well as the men of practice, should be not only recognized but rewarded, as the benefactors of the community—not rewarded, as M. Chevalier proposed, by the State, but by the community. We do not want political inventors, with a Government reward as a compensation for something other than an invention, and with their own friends to apportion it. We want for them the only true appreciator, the public.

There is no difficulty in remedying all the evils complained of in the present practice of patents. Forms of specifications can be prepared, embodying everything that is required to be stated, leaving no loopholes, and preventing verbiage, giving an exclusive privilege to make something useful, and leaving it open to competition to make something still better. The life of the inventor patentee is no lazy life. He has the public for a master, and a very exacting master too, content with nothing but the best or the cheapest, and ever ready to abandon its idol of to-day for its idol of to-morrow, succeeding each other in constant following. What do the long list of patens in the same arts mean, save that the human brain works only from step to step, eclipsing yesterday by to-day, and thus preparing the way for the morrow, a vantage-ground being gradually attained, till the process culminates in an apparent perfection, at last found to be no perfection, when a fresh start is made to a new elevation. By the sweat of the brain within his brow, the inventor diminishes human labor and the sweat of many brows, for his own profit is out of the service he renders to mankind, who will not pay for anything they do not appreciate as useful or pleasant. No State reward is needed as a stimulus to this kind of labor. The inventor only asks to be let alone to reap the crops he has himself sown, secure against depredation.

It was Prince Albert by whom the amended Patent Law, then being worked out by the Society of Arts, was finally urged, and it was Lord Granville who brought in the Bill and passed it through Parliament, in the course of a very few days, because it was believed that only thus could a number of latent inventors amongst mechanical men be brought to light for the benefit of the Great Exhibition. It was this Bill which, by reducing first cost, multiplied the number of patents, and put poor men on a level with capitalists. And it would appear that non-inventive capitalists would rather be without these patentees, and would prefer to buy up their inventions for their own purposes, and so limit the public choice in the market. Patents give a large market for constant improvements, which would not exist without them. All the large manufacturing towns and cities of England may be said to be built upon patents, and were patents abolished, the result would be similar to that of the abolition of the Edict of Nantes; the imaginative brains would depart from England, and settle down in the countries wise enough to understand their true interests. Viewed from the monopoly point, the wisest course the manufacturers could take would be, not to abolish patents, but to enhance their cost. If patents cost £5,000 each, with efficient laws to maintain them, every poor man would be shut out, and patents would become the practical monopoly that the manufacturers insist on calling them. But the motive would thus be too gross.

The subject cannot be too widely discussed, nor the facts elicited too clearly, for we cannot as a nation afford to risk our prosperity in order that a small number may grow richer at the general cost. We want a general diffusion of wealth, and not a greater aggregation in masses. Large manufactures tend to the growth of quantity rather than quality. Small manufactures tend to the growth of quality, and that diffusion of wealth so largely trenched on of late by the gigantic establisments which permit only two classes, the very rich and the very poor. The higher classes, living on incomes, the result of land or hoarded wealth, are deeply interested in the question, for it is a question of property right; and in the diffusion of property, rather than in its concentration, lies its safety. The convenience or profits of manufacturers is but a small consideration, as well as the convenience or profits of inventors. The national prosperity is the real question at issue. Shrewd Frenchmen tell us that we began patents some fifty years before them, and, therefore, they have never been able to overtake us. Were we now to abolish patents for fifty years, our human energy would be expended in producing original workers for all other nations, and excluding our own.

THE BRITISH COAL SUPPLY.

From the opening address of Sir Wm. G. Armstrong, before the Institution of Mechanical Engineers at Newcastle.

The subject of coal follows, naturally, a notice of the steam engine, and has a special interest for us, in a locality celebrated, since its earliest days of coal mining, for the production of that invaluable mineral. England, with her innumerable steam engines and manufactories, is more dependent upon coal for the maintenance of her prosperity than any other nation, and the question of the duration of her coal-fields now very properly occupies the attention of a Royal Commission. The investigations of the Commission are not yet completed; but so far as they have gone, the results are reassuring. I concur in the probable accuracy of the announcement lately made by two of my fellow commissioners, that the total quantity of coal in this island will prove to be practically inexhaustible; but until the complicated details of quantities collected by the Commission have been put together, and expressed in totals, it is difficult to judge with certainty or accuracy on the subject.

Although the duration of our coal may, geologically speaking, be practically unlimited, we have still to consider the important question, how long will England be supplied with coal as good and as cheap as at present? We have unquestionably made greater inroads into our best and most accessible coal beds than other nations have done into theirs; and if foreign coals should grow better and cheaper, and ours dearer and worse, the balance may turn against us as a manufacturing country long before our coal is exhausted in quantity. It is clear that our stock of good coal is very large; but most of it lies at great depths, and one of the most important questions the Royal Commission has to investigate is the depth at which coal can be worked with commercial advantage.

The chief obstacle to reaching extreme depth is the increase in temperature which is met as we descend. I am justified, by ascertained facts, in saying that this rate of increase will, as a rule, prove to be not less than one degree Fahrenheit for every 20 yards in depth, and there is reason to expect that it will be even more rapid at greater depths than have yet been attained. The constant temperature of the earth in this climate at a depth of 50 ft. is 50°, and the rate of increase as we descend is to be calculated from this starting point. Adopting these figures, you will find that the temperature of the earth will be equal to blood heat at a depth of about 980 yards, and, at a further depth of 500 yards, mineral substances will be too hot for the naked skin to touch with impunity. It is extremely difficult to form an opinion as to the maximum temperature in which human labor is practicable, in the damp atmosphere of a mine, and it is almost equally difficult to determine how much the temperature of the air, in the distant parts of an extremely deep mine, can be reduced below that of the strata with which it is brought in contact. It is certain, however, that the limit of practicable depth will chiefly depend upon the mechanical means which can be provided for relieving the miners of the severest part of their labor; for maintaining a supply of sufficiently cool air at the working faces of the coal, and for superseding the use of horses, which suffer even more than men from highly heated air. For the relief of labor we must look to coal-cutting machines; for improvement of ventilation to exhausting fans; and for the superseding of horses to hauling engines driven by transmitted power.

The employment of coal-cutting machines, worked by compressed air, conveyed into the mine by pipes, is already an accomplished fact, and when the difficulties and the objections which usually adhere, for a considerable time, to new mechanical arrangements are removed from these machines, they will probably attain extensive application. One of the earliest attempts at coal-cutting by machinery, was described by the late Mr. Nicholas Wood, at the former Newcastle meeting of this Institution, and all the really practical results as yet obtained date from that period. The cooling influence of the expanding air as it escapes from these machines will be a collateral advantage of considerable importance in the hot atmosphere of a deep mine. The air discharged from the pneumatic coal-cutting machines now in use in the Hetton Colliery, escapes into the mine at a temperature of seven degrees below freezing, and the cold air from each machine appears to be sufficient in quantity to lower the temperature of the circulating atmosphere by one degree. If, as seems to be probable, six or seven of these machines can be employed at each working face, we may by this means lessen the heat by a corresponding number of degrees, and thus afford very considerable relief. The employment of compressed air, as a motive power, in substitution of horse traction, is also quite feasible, and may be expected to become quite general in very deep workings. As regards ventilation, the fan machines of the several constructions tried have already exhibited great superiority over the old method of ventilating by an upcast furnace shaft; and although the efficiency of the furnace system of ventilation is increased by depth, there is reason to believe that the fan will maintain its superiority to greater depths than are likely to be reached in mining.

THE BISSELL TENDER TRUCK.—One of these trucks, put on the "fast freight" engine *Elephant*, of the Boston and Albany railroad, in January, 1868, has been run some 45,000 miles without any expense for repairs. The forward wheels, over which is the center bearing spring peculiar to Mr. Bissell's improvement, are good for many thousand miles more of service, while the wheels of the rear truck, though carrying less weight per wheel, had to be renewed some three months since. This fact, coupled with its steadiness on the track; unexampled ease in passing through curves; saving of expense in first cost, and general simplicity of arrangement, makes this device a favorite with all master mechanics who have used or seen it. Locomotive drivers all unite in desiring it to be applied to their engines.

HYDRAULIC BUFFERS.

From a paper read by Col. H. CLERK, R. A., F. R. S., before the British Association, and entitled "Description of the Hydraulic Buffers and Experiments on the Flow of Liquids through Small Orifices at High Velocities."

In consequence of a suggestion made to me in October, 1867, by C. W. Siemens, Esq., C. E., F. R. S., to try the effect of water to check the recoil of heavy guns, I submitted to the Secretary of State for War a compressor or buffer on the above principle. It has been tried with guns varying in weight from only 150 lbs. to 25 tons, and in all cases the results have been most satisfactory. The amount of recoil can be regulated to a great nicety, and the motion is smooth and regular.

It consists of a wrought-iron cylinder closed at one end, the other end fitted with a cap and stuffing-box, through which a piston-rod passes. The length of the cylinder and piston-rod are regulated by the amount of recoil required, on the space within which it is necessary to bring the moving body to rest. The piston fits well into the cylinder, and is perforated with four small holes.

The ratio between the diameter of these holes and that of the cylinder is determined by the amount of work required to be performed in the water with which the cylinder is filled, enough air space being left to allow of the displacement of water by the length of piston rod due to the recoil. This air space also acts as an elastic buffer, and takes off the violence of the first impact of the piston on the water.

The cylinder is firmly attached to the platform on which the carriage recoils, and the end of the piston rod to the carriage itself, so that on the discharge of the gun the carriage drives the piston through the water with an initial velocity (V), while the water has to pass through the holes with an initial velocity (R V), R being the ratio between the area of the cylinder and that of the holes.

This buffer has not only been used with guns on shore up to 25 tons weight, but also at sea, with light guns of only $1\frac{1}{2}$ cwt., and 8 cwt. in boats, and lately with 9 in. guns of 12 tons on board H. M. S. Prince Albert, in all cases with equal success.

In place of water it has been recommended to use oil, as there is less chance of corrosion taking place if the cylinder is kept full for any lengthened period, and no danger of the fluid freezing in ordinary frost. The oil used for this purpose is Field's Rangoon oil, which does not become thick except in very cold weather, where Field's non-freezing oil may be used. A small portion of caustic soda in the water has been found to keep the cylinder perfectly clean and free from rust for many months.

The satisfactory manner in which this buffer has worked in checking the recoil of a gun of 25 tons weight, leads me to anticipate that it could be most usefully applied towards preventing or very sensibly diminishing the destructive effects of a railway collision, for as by means of this hydraulic buffer a force of impact varying from 12,000 foot-pounds up to 54,000 foot-pounds has been easily overcome in distances from 16 to 60 in., and inclinations ranging from $+10°$ to $-4°$, I see no reason why this principle should not be extended to overcome a force of, say, 1,500,000 foot-pounds in 60 in.

In checking the recoil of a gun, the velocity to be dealt with seldom exceeds 10 or 12 ft. per second, but in case of a railway collision it is very different, for we have then to deal with very high velocities.

It is therefore necessary to ascertain how the hydraulic buffer will act under these circumstances. For this purpose I have been carrying on a series of experiments on velocities up to 44 ft. per second, or 30 miles an hour, and now forward a short account of these for the information of the members of the British Association.

Two sets of experiments have been made, one with a cylinder 4 in. in diameter, the other with a cylinder 8 in. in diameter. With both the former the velocities tried were 10, 15, 20, and 25 ft.; the second with weights of 2,324, 1,162, and 581 lbs., and with ratios between the diameter of the cylinder and the holes in the piston of 15, 21, and 27.

With the latter the velocities were 10, 15, 20, 25, 30, 35, 40, and 44 ft. per second; the weights were 1,165, 2,324, and 4,648 lbs.; the ratios 15, 12, 9, 7, and 6. The velocities were obtained by drawing a truck (loaded to the proper weight) up an inclined plane of 47° to the proper height, and suddenly releasing it (a small deduction has to be made for friction). The truck ran down the slope, and, striking the end of the piston rod, drove it in till the resistance of the water overcame all the force of impact.

The cylinder with piston rod drawn out was fixed to the bottom of the inclined plane, about two trucks' length from the end of the slope, and was securely bedded in a block of wood, propped up behind to prevent its moving. Above the cylinder was fixed a light barrel, 6 ft. in length, made to rotate at the rate of one revolution per second, on which was fixed a sheet of drawing paper; to the end of the piston rod was fixed a pencil kept in contact with the rotating barrel by means of a light spiral spring, so that at each collision the piston rod transferred to the paper a curve, showing the time occupied in passing over every portion of the space through which it was driven.

From these curves a series of Tables have been formed showing the velocity of the piston rod for every 2 in. of the stroke. The diameter of the rotating barrel was 12 in., so that one second of time was represented by a space of 37.7 in. Another pencil was attached to the truck in a similar way to the one on the piston rod; thus two motions were determined, the one of the pistons through the water, the other of the truck when in contact with the piston rod.

A disc of Clarkson's material (a combination of cork and leather) was fixed to the end of the piston rod, and another to the front of the truck, where it came in contact with the piston rod in order to deaden the force of the blow. Two discs of india-rubber were fixed to the wood block in which the cylinder was bedded, against which the truck struck in those cases where the force was sufficient to drive the piston right home. The amount that these india-rubber discs were compressed was self-registered, and the value of such compression in foot-pounds having been previously ascertained, we are enabled to estimate the remaining force with which the truck struck the cylinder block. The same relative quantities of water and air were used in all the experiments.

In 4-in. cylinder	water......	380.6	cubic in.
	air........	97.8	"
Total capacity of cylinder		478.4	"
Diameter of piston rod		1.5	"
In 8-in. cylinder	water......	2,794	"
	air........	424	"
Total capacity of cylinder		3,218	"
Diameter of piston rod........		2.375	inches.
Ratio of thickness of piston to diameter of holes..........		$2\frac{1}{2}$ to 1	"

Different descriptions of fluids, such as oil, glycerine, and methylated spirits, were tried as well as water. With a perforated piston the resistance of the water is not uniform, being greatest at the commencement, or rather at that point where the air has received its maximum compression. It was, therefore, considered desirable to try the effect of uniform resistance, and Mr. Butler (Constructor R. C. D.) suggested a very simple mode of doing this. It consisted in fixing along the length of the cylinder four tapering rods, which passed through the holes in the piston; these holes were considerably enlarged, and the smallest end of the rod being towards the front, there was a large area for the water to pass through in the first instance, gradually diminishing in proportion to the decreasing velocity of the piston, thus keeping up an uniform velocity of flow through the holes.

In order to get the effect of an air buffer, for the sake of comparison, a solid piston fitting well in the cylinder was also tried. It would exceed the limits of this paper to give all the tables of velocities and plates of curves, but I think the accompanying diagrams will give an idea of the nature of the experiments.

In Table I are included the results of all the experiments, showing the total length of stroke and time occupied in each case with velocities up to $43\frac{1}{2}$ ft. per second.

In Table II, I have shown a comparison between the actual results obtained and those calculated by the following formula, based on the assumption that the work done on the water to produce a certain velocity is equal to that which has been expended in raising the water to the height from which it would have fallen to acquire the same velocity:

$$L=\frac{W e^2}{A w R^2}\log^2\left\{\frac{A w R^2 V^2}{2 g W \omega e^2}+1\right\}$$

L=length of stroke.
W=weight of truck.
A=area of piston.
R=ratio of area of piston to orifice.
V=velocity at impact.
ω=62.5 (weight of a cubic foot of water.)
w=coefficient of friction of piston-rod, &c.
e=coefficient of discharge.

The above formula applies when the action is on water alone, and the cylinder quite full; a correction therefore is necessary on account of the air space.

It appears, from experiment, that the air is compressed into about three-fourths of its original bulk before any material resistance is offered to the piston.

Some trials were also made with the 4-in. cylinder quite full of water and a solid piston, the water being driven out of the cylinder through a 1-in. hole at the end.

The ratio in this case was 16 to 1. The difference between the length of stroke in this case and with the usual air space of 97.8 cubic inches, equal to 7.7 in. in length of cylinder, was found to be about 6 in., allowing for the slight difference in the ratios 15 and 16. In the case of the 8-in. cylinder the air space amounts to 424 cubic inches. This divided by the area gives 8.5 in. in the length of the cylinder, three-fourths of which is 6.4 in. A correction, therefore, of 6.4 in. has to be added to the calculated length in the experiments with the 8-in. cylinder, and of 6 in. in the case of the 4-in. cylinder.

The coefficient of friction, w, of the truck and piston was found by experiment to be .05 in the 8-in. cylinder, and .046 in the 4-in. cylinder.

The value of the coefficient of discharge, e, has been assumed as .58 throughout, but it appears that this value is not constant for all velocities and all weights. I am, therefore, going to make some further experiments specially to determine this point, and also to ascertain the amount of irregularity caused by the compression of the cork discs.

With these exceptions, the formula appears to give results quite near enough for all practical purposes.

The Construction of Heavy Artillery.—The name of Mr. Lynall Thomas has for long past been associated with the development of the true principles of the science of artillery. Some ten years since, he started his theory of the nature of the action of gunpowder, which he calls the percussive theory. He has now, in a pamphlet of seventeen pages, developed this theory in a most skillful manner, and has laid down the true basis upon which heavy artillery should be constructed. In order to prepare our minds for the reception of his ideas, Mr. Thomas begins by sketching the theory as laid down by Robins and Hutton, and which was even by them considered faulty. Of course it must be borne in mind that those two students in this field of science labored principally with a view of ascertaining the effects of a discharge as far as the velocity of the shot and its curved path, etc., were concerned, and the errors of their theory were not brought forth in those startling colors which more recent experiments have imparted to them. They had no such great and costly guns to deal with as we have now; and the bursting of one of their 32-pounders was not so serious a matter to them as similar accidents, which are continually depriving us of the substantial results of immense labor and expense, are to us. It soon became evident, on the introduction of heavy rifled ordnance, that not only was something wanting to render the rules laid down in the old theory applicable, but that there was some radical and serious error. Large guns which had been constructed at a fabulous cost and were regarded as most perfect specimens of mechanical ingenuity, exhibited such symptoms of premature decline, on being tested by charges less than they were intended to carry, as to baffle the skill of the most experienced engineers. Some of these destructive engines bulged, and so became unfit for service; others, although preserving their external form, were found, after being used for a short time, to have contracted in some mysterious manner a steadily corroding disease, whilst others, again, in a still more alarming fashion, burst into fragments and disappeared with the charge that rent them.

The profession was utterly unable to account for these untoward mishaps. The elder members of the profession, no doubt, congratulated themselves on having been educated in a school in which the construction of such massive pieces was never contemplated, whilst the younger members escaped from the dilemma by asserting that gunpowder was not subject to the control of the laws that regulate the operation of physical or chemical forces. In fact, these irregularities were regarded as nothing more nor less than freaks of nature. It is from this painful state of uncertainty that Mr. Thomas promises to relieve us, and we have every reason to hope, from the suggestions offered in his pamphlet, that his promise will be performed. The word "percussive" conveys to us as much information as names and definitions generally do. In the first place, it is laid down that the whole charge is not inflamed at one and the same instant. This important fact will not be disputed, as it has been already recognized by nearly every writer on the subject. Mr. Thomas then proceeds to assert that that portion of the charge which has been converted into gas impinges with a terrific velocity upon the shot, and begins to expel it before the whole charge is completely consumed, or its force fully developed. This fact, no doubt, induced Mr. Thomas to adopt the phrase "percussive theory," for, as he subsequently says, "the whole time that elapses between the ignition of the charge and the expulsion of the shot from the pieces is scarcely sensible." So far the action of the portion of the charge initially inflamed is of an impulsive or percussive nature, generating, as it does, velocity in the shot in an indefinitely short period of time. After this we arrive at the gist of the whole theory. "Whilst the shot is traversing the initial space the rest of the charge is undergoing complete conversion into gas, and when such conversion has taken place the gas rushes forth in the direction of the axis of the bore." This volume of gas by means of its kinetic energy condenses a portion of itself in that space that has been just vacated by the shot.

Mr. Thomas then proceeds to narrate how he was induced by these considerations to make a series of experiments for the purpose of ascertaining the relation between the initial velocity of the shot, its own weight, and that of the powder employed. Four laws are stated as the results of his observations. By the aid of these laws he deduces expressions for the initial velocity, the tensional strain, and the corroding effect of the pressure. It is then shown how the weights of the powder and shot may be varied according to circumstances without altering the strain on the gun.

It must be confessed that there is something very plausible in this theory; the principles which it embodies are being daily recognized by those who have had experience in gunnery. We hope that our authorities will soon take the important subject into consideration. We shall ourselves hail with delight the establishment of a theory which promises to ensure the safety and perfection of those mighty instruments for the preservation of peace, and to relieve us from the fear of having such gigantic offsprings of labor and ingenuity cut off by any more erratic freaks on the part of nature.—*Mechanics' Magazine.*

MARINE ENGINE ECONOMY.—To that large branch of the mechanical engineering profession whose members are designers or constructors of marine engines, nothing, at the late Newcastle meeting, could have afforded more interest than the fine ships building at Leslie's (of Hebburn) for Lamport & Holt, and the remarkable engines, constructing by Robert Stephenson & Co., intended to push them 30,000 miles out and home between Liverpool and China. The ships—four in number, and intended for the tea trade—are each 315 ft. long, with proportionate beam and depth. The engines, designed by Mr. Alfred Holt, are unique. For each ship there is a compound engine, working upon a single crank—a 29 in. high pressure, and 66 in. low pressure cylinder, with 4 ft. stroke of pistons. The high pressure steam is taken from boilers worked at 75 lbs. per sq. in.—boilers 9 ft. in diameter, and made of West Cumberland hematite plates, $\frac{3}{4}$ in. thick, and double riveted on all seams. It need hardly be mentioned that these boilers are fed from their own condensed steam, the surface condensers being fitted with wood ferrules. There are two boilers in each ship, each boiler having two circular furnaces at each end, making eight furnaces in all for each vessel. Each furnace is 3 ft. 6 in. in diameter, and of proportionate length, the outlet from each furnace being through a short 18 in. flue communicating with a combustion chamber at the mid length of the boiler. From this combustion chamber 90 tubes, each 4 in. in diameter, and 8 ft. 2 in. long, return to each front or furnace end, making 180 tubes in each boiler, or 360 in all for the pair. The waste products of combustion are again led back, over the boiler, through a super-heater, to a chimney common to both double boilers, with their eight furnaces. The cylinders themselves, a top high pressure and a bottom low pressure, are enclosed in a wrought-iron steam-jacket 6 ft. or more in diameter. The details of these engines are cleverly designed, and the workmanship is all that a *connoisseur* would expect from the great house of Robert Stephenson & Co., who, by the way, ought, by this time, to be commissioned by the Admiralty.

It is asserted, upon the best authority, that ships of the class under notice, with Holt's engines, make their eleven knots an hour, month in and month out, and at a rate of consumption hardly rising to 2 lbs. of coal per indicated horse-power per hour.—*Engineering.*

PRODUCTION OF STEEL RAILS.—The rail mill of Messrs. John A. Griswold & Co., Troy, is now turning out 60 to 70 tons of steel rails per day. A part of the rails are rolled from hammered blooms, and a part from ingots bloomed and then reheated before being rolled into rails. Several rail ends from each charge of steel are tested by blows from a 5-ton hammer.

HYDRAULIC SWING BRIDGES.

THE ARMSTRONG SWING BRIDGE OVER THE OUSE.

By Sir William E. Armstrong.

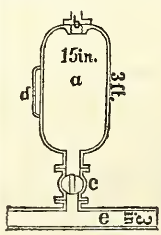
A paper read before the Institution of Mechanical Engineers at Newcastle.

The formation of the Hull and Doncaster section of the North-Eastern Railway necessitated the crossing of the river Ouse by an opening bridge, so as to admit the passage of the important traffic carried on in large sailing vessels. It was also necessary that that there should be not more than one pier in the navigable channel, with a clear opening of not less than 100 ft. on each side. The requisites of the railway and river traffic necessitated a construction that admitted of being opened and closed very rapidly. It was also necessary that the power applied should be capable of controlling with great accuracy the momentum of so ponderous a mass, and hydraulic power, being so eminently qualified for this purpose, was therefore selected as the agent. The instances in which hydraulic power had been previously applied to the opening and closing of movable bridges are very numerous, amounting to upwards of fifty examples. Most of these bridges have been erected for the passage of railway traffic, both on main lines and branches, and they may be divided into three classes. 1st. Swing bridges on which the bridge is lifted from its solid bearings by a central press previously to being turned by hydraulic pressure. 2d. Swing bridges on which the bridge rests upon a circle of two rollers, and is turned by water pressure without being lifted. 3d. Draw bridges on which the movable platform is drawn back and pushed forward in the line of the roadway by means of hydraulic machinery. In addition to the hydraulic bridges comprised in these three classes, there is one example of a bridge on the bascule plan being worked by hydraulic power. This is at Liverpool, over one of the dock entrances. The first hydraulic swing bridge was erected in 1852 over the river Severn, on the Gloucester and Dean Forest Railway, and the first hydraulic drawbridge was erected in 1853, over the river Tovey, on the South Wales Railway, near Carmathen. All the swing bridges which turn on a center pier, and span an opening on each side, have been made to turn on live rollers without being lifted; because, in bridges of that construction, neither extremity can have any steadying support in the act of turning, but in some instances a central press has been applied to relieve the rollers of part of the weight. Where single-leaf swing bridges are lifted by a central press, the deflection is taken off by letting down the bridge upon its solid bearing when closed; but in the case of drawbridges and swing bridges not lifted by a central press, hydraulic machinery is applied to lift the overhanging end or ends so as to take off the deflection after closing. The openings crossed by these various forms of bridges have varied from 30 to 100 ft. span. The heaviest bridge to which the central lifting arrangement has been applied is one over the Regent's Canal, near the London Docks, in which instance the weight lifted and turned amounts to 450 tons. In bridges with the central press, the head of the lifting ram fits into an inverted cup upon the bridge to allow of oscillating movement, and the bridge in swinging turns upon the water by carrying the ram 'round with it. The pressure of water employed in the central hydraulic press is about 800 lbs. per square inch, and in the largest of these bridges the diameter of the ram turning upon the water is 51 in. In most cases the bridges are in connection with a system of hydraulic pressure applied to cranes and other machines in the vicinity, the pressure being supplied in the usual manner by steam engines pumping into accumulators. But in some few instances, where there is not such a supply of power at hand, the pressure is supplied by hand pumps charging the accumulator, and thus storing up the power ready for application whenever required. At the Ouse Bridge there was no supply of hydraulic power at hand, and in that instance the total power required was too large to be supplied by hand labor. It was further necessary, on account of the position of the swing bridge, either to convey the power to the center pier by a pipe under the bed of the river, or to produce it upon the pier by placing a steam engine within the pier itself, and the latter plan was adopted.

The total length of the bridge, fixed and movable, is 830 ft. The fixed portions consist of five spans of 116 ft., from center to center of piers. The bridge being for a double line of railway, each span is composed of three wrought-iron girders of the bow-string form, the center girder having a larger section to adapt it for its greater load. These girders have single webs, and are 9 ft. deep in the center. The total width of the bridge, from outside to outside, is 31 ft. Each of the piers for the fixed spans consists of three cast-iron cylinders, of 7 ft. diameter and about 90 ft. in length. The depth from the under side of the bridge to the bed of the channel, in the deepest part, is about 61 ft. The headway beneath the bridge is 14 ft. 6 in. from high water datum and 30 ft. 6 in. from low water. The swinging portion of the bridge consists of three main wrought-iron girders, 250 ft. length and 16 ft. 6 in. deep at the center, diminishing to 4 ft. deep at the ends. The center girder is of larger sectional area than the side girders, and, instead of being a single web, is a box girder 2 ft. 6 in. in width, with web plates $\frac{7}{16}$th to $\frac{5}{16}$th in. in thickness, and the top and bottom boom contains about 132 sq. in. of section. The roadway is carried upon transverse wrought-iron girders resting upon the bottom flanges of the main girders. In the center of the bridge the main girders are stayed by three transverse wrought-iron frames securely fixing them together; and over the top of these frames a floor is laid, from which the bridge man controls the movements of the bridge. An annular box girder, 32 ft. mean diameter, is situated below the center of the bridge, and forms the cap of the center pier; this girder is 3 ft. 2 in. in depth, 3 ft. in width, and rests upon the top of six cast-iron columns, each 7 ft. diameter, which are arranged in a circle, and form the center pier of the bridge. Each of these columns has a total length of 90 ft., being sunk about 29 ft. deep in the bed of the river. A center column, 7 ft. in diameter, is securely braced to the other columns by a set of cast-iron stays, which support the floor of the engine-room. This center column contains the accumulator, and forms the center pivot for the rotation of the bridge. The weight of the swing bridge is 670 tons. There is no central lifting-press, and the entire weight rests upon a circle of conical live rollers. These are 26 in number, 3 ft. diameter and 14 in. width of tread, and are made of cast-iron, hooped with steel, and they run between two circular roller paths 32 ft. diameter. These roller paths are 15 in., and are made of cast-iron, faced with steel; the axles of the rollers are horizontal, and the two roller paths are turned to the same bevel. The turning motion is communicated to the bridge by means of a circular cast-iron rack $12\frac{1}{2}$ in. wide on the face, and $6\frac{1}{2}$ in. pitch. It is shrouded to the pitch line, and is bolted to the outer circumference of the upper roller path. It gears with a vertical bevel wheel, which is carried by a steel center pin, supported on the lower roller path. This is driven by a pinion connected by intermediate gearing with the hydraulic engine. There are two of these engines, duplicates of one another, either of which is sufficient for turning the bridge. The force required to turn the bridge is equal to about ten tons applied at the radius of the roller path. Each hydraulic engine is a three-cylinder oscillating engine, with simple rams $4\frac{1}{4}$ in. diameter and 18 in. stroke. These engines work at 40 revolutions per minute, with a pressure of water of 700 lbs. per inch, and are estimated at 40-horse power each. The steam engines for supplying the water pressure are also in duplicate, and are double cylinder engines, driving three throw pumps 2.8 in. diameter and 5 in. stroke, which deliver into the accumulator. The diameter of the steam cylinders is 8 in., and the stroke of the piston is 10 in., each engine being 12-horse power, The accumulator consists of $16\frac{1}{2}$ in. ram, with a 17 ft. stroke, and is loaded with a weight of 67 tons, the weight being composed of cast-iron segments suspended from a crosshead and working down in the cylindrical casing formed by the center cylinder. For the purpose of obtaining a perfectly solid roadway when the bridge is in position for the passage of trains, and also for securing the perfect continuity of the line of rails, the following apparatus is applied: Each extremity of the bridge is lifted by a horizontal hydraulic press acting upon levers, forming a toggle joint, the piers having two rams acting in opposite directions upon two toggle joint levers, which act one upon each side of the end of the bridge, and they are connected by a horizontal bar, which is confined by a stud sliding in a vertical guide, so as to ensure parallel action of the two toggle joint levers, and producing exactly parallel lifting of the two sides of the bridge. Three resting blocks, one under each girder, are pushed home when the end of the bridge is lifted by means of two separate hydraulic cylinders, and the bridge is then let down upon the resting blocks by the withdrawal of the toggle joint levers, and the bridge ends are then perfectly safe for trains to pass over. The hydraulic cylinders for this fixing gear at the two ends of the bridge are worked by the bridgeman from the center platform by means of two levers, and for the purpose of enabling him to regulate the stopping of the motion of the bridge at the right place an indicator is provided, consisting of a dial upon a pedestal. This dial has two pointers, which are actuated by the motion of the bridge. One of these two pointers makes two revolutions, and the other 42 revolutions for one complete rotation of the bridge. These pointers are similar to the hour and minute hands of a watch, the slower pointer being analogous to the hour hand, and the quicker one to the minute hand. The bridge has no stop to its movement, and would swing clear past its right position if the turning power were continued; but the bridgeman, being guided by the indicator, knows when to stop and reverse the hydraulic engines for the purpose of stopping the bridge at its right place. When this is done, a strong bolt, 3 in. thick, in each end of the bridge, pressed outwards by a spiral spring, is shot into a corresponding notch in the fixed girder work, so as to lock the bridge; and when the bridge is required to be opened, these bolts are withdrawn by a wire cord leading to the platform on which the bridgeman is stationed. As the accumulator is stationary, and the fixing gear at the ends of the bridge travels with the bridge, the communication of water power is made by a copper pipe passing up in the axis of the bridge through the middle of the center girder, having a swivel joint at the lower end. Also, as the hand gear for the bridgeman rotates with the bridge, while the hydraulic turning engines are stationary, the communication for working the valves is made by a copper rod passing down through the center of the above pressure pipe in the axis of the bridge. This rod is connected by levers direct with regulating valves of the hydraulic engines, and the engines are reversed in either direction by the action of a small hydraulic cylinder, which is governed by the movement of a three-port valve, actuated by this rod from the bridgeman's platform. The cylinders for working the fixing gear at the ends of the bridge are worked by valves placed upon the center platform in reach of the bridgeman, the pipes between the valves and the cylinders passing along the side of the roadway of the bridge. The time required for opening or closing the bridge, including the locking of the links, is only half a minute, the average speed of motion at the extremities of the bridge being $6\frac{1}{2}$ ft. per second. For the purpose of ensuring safety in the working of the railway line over the bridge, a system of self-acting signals is arranged, that is actuated by the fixing gear at the two ends of the bridge, and a signal of 'all right' is shown by a single semaphore and lamp on the fixed part at each end; but this cannot be shown until each one of the resting blocks and bolts is secured in its proper place.

A Syphon for Draining a Tunnel.—The tunnel through the Blue Ridge, in Virginia, is 4,273 ft. long, and 700 ft. below the top of the mountain; on this account it was thought expedient to construct without shafts. This tunnel slopes from west to east, at the rate of 70 ft. to the mile, so that on the west side, the water, which proved very abundant and troublesome, had to be removed by artificial means. For some distance at the entrance, I determined to introduce a syphon of unusual length, which proved a difficult and, at the same time, interesting experiment.

The whole length of the syphon is 1,792 ft., viz: 563 ft. inside of the tunnel, and 1,229 ft. outside. The level of the water inside is upwards of nine feet below the summit, and the fall outside $29\frac{1}{4}$ ft., so that the head is a fraction over 20 ft. Iron faucet pipes of three in. interior diameter were adopted. It was feared that larger ones would carry along too much air; and that the syphon would have to be fed too often at the summit, an apprehension which the results observed seem to justify. A common faucet cock is placed at each end, to close the syphon when it becomes necessary to fill it again with water; and at the summit a large air vessel is provided to collect the air disengaged from the water, with a suitable opening at top, to let the air out and replace it with water; this opening being closed by a cap tightly screwed down. At the bottom of the air vessel, there is besides a large cock, which is closed while the syphon is being fed through the top opening, so as not to interrupt the running of the syphon during the operation.



The annexed diagram represents the air-vessel *a*; *b* is the cap; *c* the cut-off cock; *e* the main pipe or syphon; *d* is a glass tube for observing the level of the water. This, however, being often broken, was dispensed with at last; the level of the water being easily ascertained by knocking against the air-vessel.

Things being now disposed as described, it might be supposed that the discharge would have gone on uninterruptedly, requiring only a careful attention to replenish occasionally with water the air vessel; but such was not the case; at first the joints had been made tight by packing with oakum and then thickly pitched over. The syphon was filled with water through the air-vessel, which being then closed and the ends open, the water began to flow; but this did not continue for more than five or ten minutes, when the air-vessel was found empty of water, and had to be replenished at these short intervals; moreover, notwithstanding this tedious repetition of feeding the syphon, it would ultimately run dry in about two hours.

This was a truly discouraging circumstance; we ascribed it to the fact that, there being upwards of 200 joints, air was introduced in small bubbles through the oakum packing by the external pressure at every joint, and that it accumulated rapidly all along, especially in the longer arm of the syphon, which soon became too light. Accordingly, we decided not to abandon the enterprise, but to caulk the joints with lead in the usual way, which was not done before for motives of economy, and because, it being only a temporary fixture, it would have been more easily taken apart.

This operation was not yet entirely successful, though the caulking was made so hard that many of the bells broke in packing, without making the joints perfectly impermeable. Then a cement was made of equal parts of white lead and red lead mixed to the consistency of soft putty, with equal quantities of Japan varnish and boiled linseed oil. This cement, carefully coated over the joints, made them at last perfectly tight. The syphon, thus improved, runs now regularly. Still the air-vessel must be replenished with water every two hours, which is done by a pipe leading from a spring, and, moreover, every six hours the ends must be closed, and the whole syphon filled in anew with water; otherwise it would run dry.* It is probable that, owing to its being so long, and consequently so level, bubbles of air travel along very slowly and increase in size gradually; possibly some air may find its way under external pressure through the iron itself.

* Would not this be remedied by making the air-vessel *self-acting* like the air valves sometimes used on water mains?—*Note by J. C. Trautwine.*

A curious circumstance took place in the beginning: the tunnel having progressed much beyond the well of the syphon, and the water considerably increased, a horse power with chain pumps was constructed at the further end to pump up the water into troughs, by which it is led to the syphon well. Here, the syphon being insufficient for this accession of water, another horse power was introduced to pump up water out of the same well. As soon, however, as the chain pumps began to revolve in the well, the syphon suddenly stopped and we were obliged to dig a separate well for it; since which time both have worked well.

The syphon, by actual measurement, when just replenished, discharges $43\frac{1}{2}$ gallons per minute, whereas, all known formulæ give between 54 and 60 gallons, and furthermore, in "Weale's Engineers' and Contractors' Companion," occurs this conflicting remark, taken from R. A. Peacocke's work:

"By Dr. Young's formula (considered by him the best)—

A 5-inch	pipe	would	be used	where a	$3\frac{1}{2}$	would suffice.
7	"	"	"	"	5	"
10	"	"	"	"	7	"
14	"	"	"	"	10	"

and then he goes on to show the useless expenditure resulting from pipes too large being used in obedience to these formulæ. But here in this extraordinary long syphon, his opinion is not sustained, and we find, on the contrary, the discharge is less than the formulæ give; and that neither they nor Mr. Peacocke's rules are applicable to this case.

The syphon I have described is, I believe, the longest ever attempted to be used, and on this account the results and anomalies it presents are somewhat interesting. It certainly has rendered considerable service in the Blue Ridge Tunnel; with no other current expense than the employment of a man to attend to the air-vessel.—*Col. C. Crozet in Journal Franklin Institute.*

TESTING RAILS AND AXLES.—A suitable movable anvil, to be placed temporarily upon the flat anvil of a heavy steam-hammer, makes a convenient testing machine. It has been proved by experiment that a 5-ton hammer falling 20 inches upon a rail having one foot bearings, is about equivalent to a 1-ton weight falling ten feet upon a rail having three feet bearings.

ON THE THERMAL ENERGY OF MOLECULAR VORTICES.

Abstract of a paper before the Royal Society of Edinburgh, by W. J. MACQUORN RANKINE, F. R. S., &c.

In a previous paper, presented to the Royal Society of Edinburgh in December, 1849, and read on the 5th of February, 1850 (Trans. vol. xx.), the author deduced the principles of thermodynamics, and various properties of elastic fluids, from the hypothesis of molecular vortices, under certain special suppositions as to the figure and arrangement of the vortices, and as to the properties of the matter which moves in them. In subsequent papers he showed how the hypothesis might be simplified by dispensing with some of the special suppositions. In the present paper he makes further progress in the same direction, and shows how the general equation of thermodynamics, and other propositions, are deduced from the hypothesis of molecular vortices, when freed from all special suppositions as to the figure and arrangement of the vortices, and the properties of the matter that moves in them, and reduced simply to the following form: *that thermometric heat consists in a motion of the particles of bodies in circulating streams, with a velocity either constant or fluctuating periodically.* This, of course, implies that the forces acting amongst those particles, are capable of transmitting that motion.

The principal conclusions arrived at are the following:

1. In a substance in which the action of the vortices is isotropic, the intensity of the centrifugal pressure per unit of area, is *two-thirds* of the energy due to the steady circulation in an unit of volume. The centrifugal pressure is the pressure exerted by the substance in the perfectly gaseous state.

2.* If there be substances in which the action of the vortices is not isotropic, then in such substances the proportion already stated applies to the mean of the intensities of the centrifugal pressures in any three orthogonal directions.

3.* The proportion which the whole energy of the vortices, including that of the periodic disturbances, bears to the energy of the steady circulation alone, may be constant or variable.

4. Absolute temperature is proportioned to the energy of the steady circulation in unity of mass, and to the specific volume in the perfectly gaseous state.

5. In substances which are nearly in the perfectly gaseous state, experiment shows the proportion in which the whole energy exceeds that of the steady circulation, to be sensibly constant; and its value may be found by computing in what proportion the dynamical value of the specific heat at constant volume exceeds once and a half the quotient found by dividing the product of the pressure and volume by the absolute temperature. *The following are examples:—air, 1.634; nitrogen, 1.630; oxygen, 1.667; hydrogen, 1.614; steam-gas, 2.242.

6. The known general equation of thermodynamics is deduced from the hypothesis of molecular vortices, *freed from the special suppositions made in the paper of 1849-50.

The new conclusions obtained in the present paper are marked *. Those not so marked were arrived at in the paper of 1849-50.

The general equation of thermodynamics is here stated for convenience; let dQ be the thermal energy which must be given to unity of mass of a given substance, in order to produce a given indefinitely small change in its temperature and dimensions: then—

$$dQ = \tau \; d \cdot \phi;$$

in which τ is the absolute temperature, and ϕ the thermodynamic function. The value of that function is—

$$\phi = Jc \text{ hyplog } \tau + \chi(\tau) + \frac{dU}{d\tau};$$

Jc being the dynamical value of the real specific heat; U, the potential energy of the elasticity of the body at constant temperature; and $\chi(\tau)$, a function of the absolute temperature, which is null or inappreciable in a substance capable, at that temperature, of approximating indefinitely to the perfectly gaseous state, and is included in the formula, in order to provide for the possibility suggested by Clausius, that there may be substances which have not that property at all temperatures.

THE CONNECTICUT WESTERN RAILROAD, a link in the Boston, Hartford and Erie, now building, will undoubtedly pay as a trunk line, but its chief value to the public, and ultimately to shareholders, will be the facilities it will afford for bringing cheap coal to the many manufacturing villages of Connecticut, and for carrying the excellent iron ores of the Salisbury and adjacent regions to the Hudson river, there to be smelted with anthracite coal.

AVELING & PORTER'S TRACTION ENGINES.

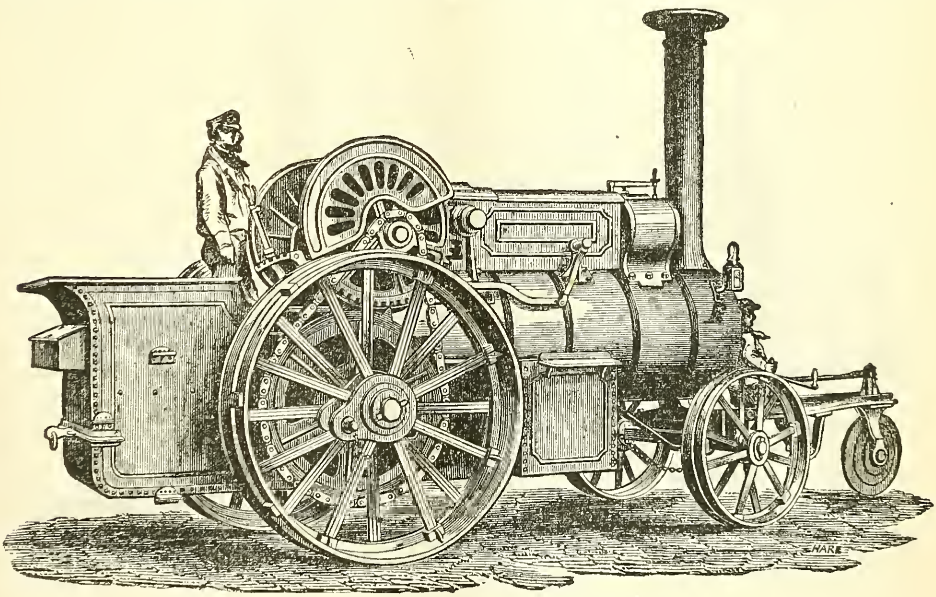
AGRICULTURAL LOCOMOTIVES AND TRAMWAY ENGINES.

The subject of Traction engines as locomotives for ordinary roads and for agricultural and other purposes, is attracting a large amount of attention in this country, but certainly not more than its vast importance entitles it to. In the London Exhibition of 1851, there was not one Traction engine, and it was the general belief that none could be contrived to answer any commercial purpose. In the London Exhibition of 1862, nine of these engines were exhibited. At the Royal Agricultural Society's meeting at Canterbury in 1860, Mr. Aveling, of Rochester, exhibited a self-propelling engine, but it was regarded with indifference by the officers of the society, and was catalogued with the "miscellaneous" articles.

Since that time, however, the importance and advantages of self-propelling engines over the ordinary "Portable engines," which have to be conveyed from place to place by horse-power, or otherwise dragged heavily along by a vast expenditure of manual labor, is an admitted fact, and not only are these Traction engines employed for agricultural purposes, but they can be seen in successful operation in England and many other parts of the world—in the timber yard, at the coal-field, the copper mine and the stone quarry, where they are doing the work of horses at less than half the cost.

The illustrations accompanying this article are perspective views of road locomotives and tramway engines as manufactured by Messrs. Aveling & Porter, of Rochester, England, and 43 Exchange Place, New York, who are amongst the most successful English makers of this description of engine.

Aveling & Porter's Patent Road Locomotive engine is arranged with double gearing to travel at two speeds, viz: $2\frac{1}{2}$ miles and 5 miles an hour. The working parts are housed in from the influence of dust and weather. This engine has one cylinder placed on the forward part of the boiler and surrounded by a steam-jacket, at the top of which is placed the throttle-valve. Priming in ascending steep inclines is thereby prevented, and the use of steam-pipes, either inside or outside the boiler, is avoided. Engines with single cylinders and reversing gear when connected to the driving axle by means of Aveling's patent chain gear, have proved themselves to be thoroughly efficient, more powerful, less complicated, and in many respects better adapted for general traction purposes than engines with double cylinders. The driving-wheels are 6 ft. 6 in. diameter, and 18 in. wide, and have spaces in the face in order to



Aveling & Porter's Patent Road Locomotive or Traction Engine.

fix on angle-iron paddles when passing over soft ground. Small castings slide into these spaces when the angle irons are not in use. Either of the driving-wheels can be rotated at pleasure, which is a great advantage in turning sharp curves. The tanks carry water and fuel for a run of from six to ten miles, according to the speed. A powerful friction-break is connected with the driving axle, and the patent arrangement for steering the engine is perfect in its action.

A most elaborate series of experiments have been lately made with one of Aveling & Porter's road traction engines, "La Ville de Senlis," at Beaurain, France. The experiments were conducted by M. Tresca, Engineer, Sub-director of the Conservatoire Impérial des Arts-et-Métiers, Paris, and approved by the Director-General, Moran. The experiments moreover were made in concert with Professor Fleeming Jenkin, F. R. S., London, whose presence gives to the results arrived at, a character of security that increases their importance.

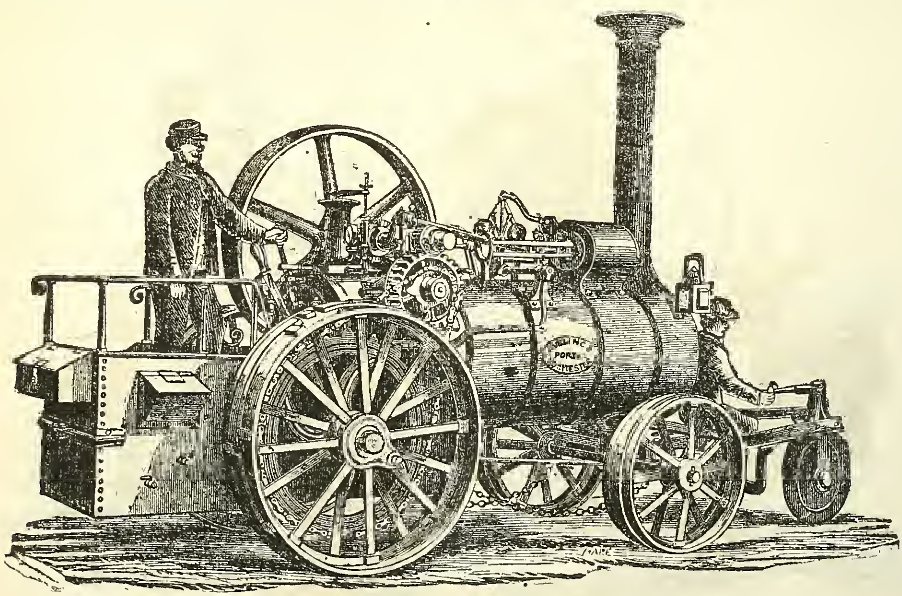
Soon after the Paris Exposition of 1867, a number of experiments having for their purpose the testing of the tractive power of Aveling's engine, were made with the engine "Pioneer," and these have been lately supplemented by more detailed and searching tests applied to the engine "La Ville de Senlis," manufactured by the same firm. The report, which is a very lengthy and carefully compiled paper, concludes as follows:

"To sum up. The engine (La Ville de Senlis) drew in a regular manner, upon a good road slightly undulating, a total load of 60,000 kilog. (59 tons). The co-efficient of traction may be approximately estimated at $\frac{1}{40}$, which would bring the mean strain to nearly 2,000 kilog. ($39\frac{1}{2}$ cwt.) taking into account the weight of the locomotive.

"This mean effort, developed at a speed of 1.108 m. (3.54 feet) per second, brings the valuation of effective work to 2,160 kil. met. (15,623 foot-pounds) per second, or to 28 chevaux vapeur (27.61 horse-power). This figure will appear high if it be compared with the consumption of fuel, which was 184 kilogrammes, (3 c. 2 q. 13 lbs.) in three hours and three minutes, say 60 kilog. (132.25 lbs.), per hour of actual traveling. This consumption represents only 2 kilogrammes (4.40 lbs.) of coal per horse-power and per hour.

"The corresponding consumption of water is not less than 600.46 liters (132.22 gallons) per hour of actual traveling. With the present tenders, which can hold 1,800 liters (396 gallons) of water, it is necessary to replenish them every 10 or 12 kilometers ($6\frac{1}{2}$ to $7\frac{1}{2}$ miles).

"The co-efficient of adherence may be estimated on the road gone over at .3 of the adherent weight.



Aveling & Porter's Agricultural Locomotive.

"The adherence resulting therefrom was only necessary for the working of the engine up inclines of .030 to .033 (1 in 33 to 1 in 30) and at starting.

"The load of 81,253 kilogrammes ($79\frac{1}{2}\frac{9}{0}$ tons) which the engine drew on level ground is not the limit of what it can draw under these conditions.

"The speed of four kilometers (2.48 miles) per hour appears suitable for fraffic of this nature, and renders the manœuvers so easy that the train is well managed by a superintendent, an engine driver, and an assistant solely employed to guide the steering wheel in front.

"Done by the Engineer, Sub-Director of the Conservatoire Impérial des Arts-et-Métiers.

"PARIS, 15*th January*, 1868.

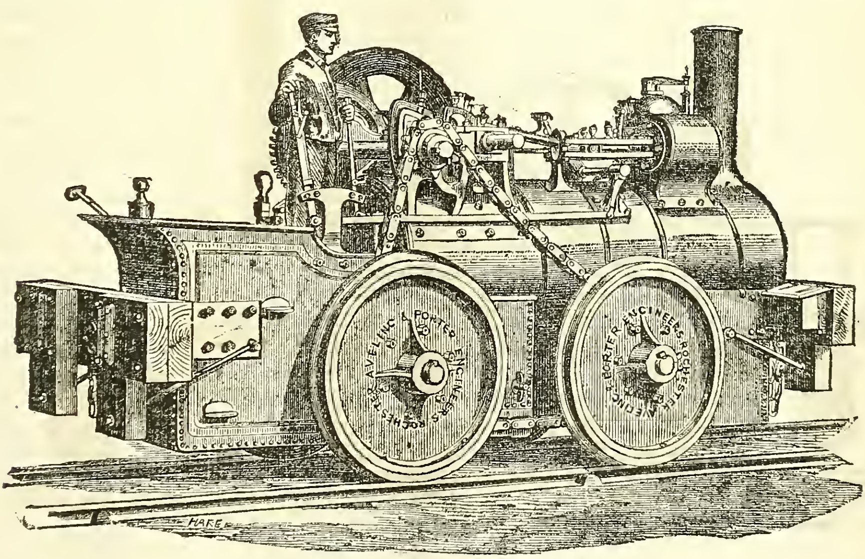
"H. TRESCA.

"Approved—The Director.

"GENERAL MORAN."

It is upon the general principles adopted in the manufacture of Aveling & Porter's road traction engine, that their agricultural locomotive has been designed. The second illustration gives a view of this machine, which is especially adapted for steam cultivation, thrashing, sawing, pumping, and removing agricultural produce. The boiler is unusually large; it is clothed entirely with hair felt, lagged and covered over with sheet-iron, and proved to a pressure of 200 lbs. to the square inch. Want of heating surface, and the use of steam pipes inside the boiler, causing loss from leakage and waste in reheating the exhaust steam on its passage to the atmosphere, are serious faults common in agricultural engines. In this engine the cylinder is placed on the forward part of the boiler, surrounded by a steam-jacket, and with arrangements otherwise similar to Aveling's road locomotive. The driving wheels are 5 feet 6 inches diameter, and 16 inches wide. The engine is capable of taking a load of from 10 to 15 tons over ordinary roads. There are 400 of these engines in use in England and many countries of the European continent, and the testimony of the best and most competent judges affirms the superiority and economy of the agricultural locomotive over all descriptions of engines used for farm purposes. The simple "Portable engine," without any capacity for propelling itself, is but a small "half measure" towards economy, and the difference in the cost of a locomotive and an engine which necessitates the expenditure of much time and expense for its removal is so trifling when compared with the advantages gained by the newer methods, that there is little doubt of the ultimate adoption in this country of a plan that has proved so entirely successful abroad. The prize medals of the International Exhibition, London, 1862, and the Universal Exhibition, Paris, 1867, were awarded to this engine.

The third illustration exhibits a locomo-



Aveling & Porter's Patent Tramway Engine.

tive so constructed as to be worked upon an ordinary tramway, and may be described as a traction engine placed upon railway wheels, these wheels being coupled by the pitch-chain, which is employed to communicate the motion to them. These engines are made from 4 to 30 horse-power. From the crank-shaft the motion is communicated by spur gearing to a countershaft, carrying at its end the wheel for the pitch-chain, the bearings of this shaft being placed in curved slots formed in the supporting brackets, so that the shaft can be raised and the chain tightened when necessary. The crank-shaft carries a fly-wheel, and the engine is fitted with Aveling's usual link-motion reversing gear. The pitch-chain extends from the countershaft around the chain wheels, fixed one inside each of the carrying wheels, and the chain thus couples the wheels together, as well as communicates the motion of the countershaft to them. The carrying wheels are 4 ft. diameter, and are placed at a distance of 5 ft. 3 in. apart from center to center, the leading axle passing under the barrel of the boiler, and the trailing one being placed behind the fire-box casing. The wheels are of cast-iron, and the total weight of the engine (a 10-horse power) 9 tons. These engines have the same advantages as portable and stationary engines for pumping, sawing, and driving fixed machinery; they are capable of taking heavy loads at the rate of six miles per hour, and at a cost of three farthings per ton per mile. They are in use in Her Majesty's dockyards at Chatham, Portsmouth and Davenport, and in many mines, quarries, brick-fields and other large works in England and other European countries.

In all parts of the United Kingdom are to be found these tramway engines; and horse-power, which was formerly employed for working in mines and quarries, has, in a great number of cases, been replaced by locomotives, and the cost of traction has thereby been materially reduced.

Altogether these engines have given abundant proof of being well adapted for use in quarries and similar places where heavy loads have to be moved at slow speeds, and in such situations it appears that they will do the work at about half the cost incurred by the employment of horse-power. W.

THE BAD COAL BURNING on most of our locomotives is a waste of money, a nuisance to passengers, and a disgrace to managers.

THE SPIRIT-LEVEL.

By JOHN PHILLIPS.

From "The Builder."

Its Invention.—He who first filled a glass bottle with a liquid, leaving a small quantity of air therein to form a bubble, then corked the bottle and laid it flat on one side, with the bubble floating against the upper part, was the unconscious inventor of the spirit-level, which is a very simple instrument in appearance, but of the utmost value, when properly made, to the astronomer, the engineer, and the builder; for when the bottle is placed horizontally, the bubble always mounts to, and rests at, its most elevated point; and the tangent to that point, when the middle or apex-point of the bubble coincides therewith, is a horizontal line; that is, a line at right angles, or perpendicular to the direction of gravity or the plumb-line passing through that point.

This was first perceived and applied, so far as is known, in France in 1666, by Melchisédec Thévenot, who was a great amateur of science, and a writer of books of voyages and travels. In this respect he enriched the literature of France as much as Hakluyt enriched that of England half a century earlier. It was at Thévenot's house that the learned men who founded the Academy of Sciences at Paris used to assemble; and it was at one of their meetings that he propounded the spirit-level.

A description of the instrument, accompanied with figures, was first published in the "Journal des Savants," Paris, November 15th, 1666, under this title: "Machine nouvelle pour la conduite des eaux, pour les bâtiments, pour la navigation, et pour la plupart des autres arts." The instrument is there called an *air-level;* and is described as a glass tube, hermetically sealed at both ends, containing spirits of wine, which do not freeze, and a small quantity of air forming a bubble. It is stated that the instrument is capable of giving, with much exactness, the direction of the horizon, the perpendicular to the horizon, and vertical angles; and that it is easier to make, more convenient to use, and indicates a level line more readily and accurately than any other instrument. One figure represents the tube charged with liquid, and an air-bubble; a second shows it fitted, under the center part, with a spindle dropping into a socket fixed on a staff so as to turn in any direction, and with sights on the ends for leveling to long distances; a third represents it fixed to a square, and a fourth to a short flat bar of wood, as levels for workmen; and a fifth shows it fixed to a quadrant for navigation.

In this first publication the inventor is not named. But in a small work, called "Recueil des Voyages de M. Thévenot," Paris, 1681, there is a description of the instrument by Thévenot, preceded by a statement that he invented it fifteen years before that time; and that he then gave a description of it to the public. This agrees with the description in the "Journal des Savants," referred to above, which no doubt was written by Thévenot himself. He also states that soon after its invention an account of it was sent to the Royal Society of London. The celebrated Dr. Hooke was then a constant attendant at the meetings of this body. By this means he became acquainted with it; and seeing that it would be of the greatest advantage to astronomy, to navigation, to engineering, and to building, he had some excellent tubes prepared, and applied them to various instruments; and he subsequently produced the spherical spirit-level. From this circumstance the invention of the spirit-level, now in common use, has been ascribed to Hooke, but it is undoubtedly due to Thévenot. Much merit is due, however, to Hooke for aiding to perfect it, and to apply it to science. He was the best practical mechanician of his time, as is evidenced by his numerous valuable inventions. He, as well as Wren, whose name is displayed in the most prominent of red-letters on the fame-roll of British architects, were contemporary with Newton; and both Hooke and Wren were within an ace of seeing and propounding the principle of universal gravitation at the moment when the great intellect of Newton had grasped and mastered it,—dispelling forever the mist that had obscured it.

As, however, the instrument was new, and there were difficulties in constructing it with precision, nearly a century elapsed before those difficulties were removed, and it obtained the preference it merited over the water-levels and plumb-levels then in use, as well as over those that were invented during the interval, most of which are now almost forgotten. It was first practically employed in this country, in 1756, by Smeaton, for leveling the foundation and courses of stone of the noble lighthouse which he designed and erected on the Eddystone. Thévenot's simple glass tube is now applied to nearly all the instruments used in leveling, and it is *the* level *par excellence.*

Its Construction.—The spirit-level, as ordinarily constructed, consists of a short cylindrical glass tube, whose interior surface is, or should be, ground to a slight regular curvature lengthways, and then polished. The curvature, which is much exaggerated in the figure, is almost imperceptible in the tube, the radius being from 300 ft. to 600 ft. The tube is nearly filled with a very limpid liquid, leaving a small space occupied by an air-bubble. The open ends are then hermetically sealed by melting the glass around them with the blow-pipe.

Alcohol or sulphuric ether, whose specific gravities are respectively .792 and .715, water being 1.000, are preferred for charging the tube, because these liquids are much lighter, possess the property of fluidity in a higher degree, and are more sensitive than any others. Moreover, intense frost does not affect their fluidity—no observed degree of natural or artificial cold having ever frozen them; and they also have the property of wetting the glass more readily and completely than other liquids, owing to the greater capillary affinity subsisting between them and the glass.

If the tube's curvature were the same as the earth's curvature, the upper line or surface of the liquid would be truly level, and therefore no part of it would have a tendency to fall, or seek a lower position; nor would the bubble, which is considerably lighter than the liquid, have a tendency to rise or seek a higher one, but would remain uninfluenced at any part, because the action of gravity upon the surface of the liquid would be everywhere precisely equal. It is essential, therefore, that the tube should be made not only of equal bore, or perfectly cylindrical throughout, but with a uniform and sensibly convex curvature, lengthways, in order that the middle or apex-point of the bubble may rise to, and rest at, the middle or apex-point of the arc.

As, then, the bubble moves in an arc of a circle convex upwards, it may be regarded as a *plummet of air*, analogous to a plummet of metal or a pendulum swinging in the arc of a circle convex downwards; and the center of gravity of the bubble is brought to rest, by the earth's attraction, in the vertical line passing through the center of the circle in the arc of which the bubble moves, the same as the center of gravity of the plummet or the pendulum is brought to rest, also by the earth's attraction, in the vertical line passing through the center of the circle in the arc of which the plummet or the pendulum swings, or through the point from which they are suspended. When, therefore, the apex-point of the bubble coincides with the apex, or zero-point, as it is called, of the tube, which is marked thereon, or the ends of the bubble mark equal distances therefrom, the instrument is in adjustment—that is, the tangent to the tube at the zero-point is horizontal, or at right angles to the vertical passing through that point.

Two symmetrically divided scales are usually engraved across the top surface of the tube—one on each side of the zero-point, or one from each end of the bubble when its apex-point is identical with the zero-point; so that when the bubble marks equal divisions on the scales, the tangent to the arc at the zero-point, as also a visual ray, a straight edge, or a line parallel thereto, is horizontal. When, on the contrary, one end of the tube is raised above the other, the bubble runs from the zero-point towards the elevated end, and the tangent to that point, or the visual ray, the straight edge, or the line parallel thereto, inclines upwards in one direction, and downwards in the other, from exact horizontality, while the tangent to the arc at the apex-point of the bubble, wherever situated, remains horizontal.

When, therefore, the radius of curvature of the tube is known, the scales across the tube are capable of measuring vertical angles with the same accuracy as a sector, whose radius is equal to the radius of the tube's curvature. Thus, when the apex-point of the bubble deviates from the zero-point of the tube, the value in seconds of the angle contained between the horizontal tangent to the bubble's apex-point, and the tangent to the tube's zero-point is

$$206265'' \times \frac{\text{deviation of bubble.}}{\text{rad. of curv. of tube.}}$$

For example, let the bubble's deviation from the zero-point be three divisions of the scale, or $\frac{3}{10}$ of an inch, and let the tube's radius of curvature be 300 ft.; then we have $206265'' \times \frac{3}{300} = 206265'' \times .01 = 2062''.65 = 34'\ 22''.65$, the value of the angle from horizontality.

The radius of curvature of the tube may be found by the formula

$$R = \frac{d}{h} D;$$

where R is the radius, d the deviation of the bubble, h the height traversed on a distant staff by the run of the tangent from the tube's zero-point to the bubble's apex-point, and D the horizontal distance from the bubble's apex-point to the staff. Let $d = .5$ inch, $h = 1$ inch, and $D = 600$ feet; then $R = \frac{d}{h} D = \frac{.5}{1} \times 600 = .5 \times 600 = 300$ feet.

Hence the longer the radius the less will be the curvature of the tube, and the more sensible will be the bubble of any deviation of the tangent to the tube's zero-point from the horizontal; because the bubble must move over a greater length of the tube in proportion to any small elevation of either end. In delicate levels the curvature is very small, and the bubble quivers with the slightest touch or tremor; while in levels made for common use the curvature is more rapid, and the bubble is more readily brought to a stand, and remains steadier.

The volume and length of the bubble are affected by every change of temperature. The glass and the liquid both expand—the glass very slightly, the liquid very considerably. If they expand equally, the capacity of the tube and the volume of the liquid would be enlarged in the same proportion, and the volume and length of the bubble would remain always the same. But, as just observed, the dilitation by heat of the glass is only slight, while that of the liquid is very considerable. Hence the capacity of the tube increases much less than the volume of the liquid; and hence the volume and length of the bubble become smaller as the volume of the liquid becomes larger. This may be verified by heating the tube; when, as the liquid receives heat and expands, the volume and length of the bubble will be seen to decrease; and also by cooling the tube, when, as the liquid parts with heat and contracts, the bubble will be seen to increase in volume and length. Alcohol expands regularly $\frac{1}{1800}$ for every degree of heat that it receives above 32°, and it contracts with the like regularity for every degree of heat it parts with below 32°.

In common levels the tubes are used just as they leave the glass factory. Those having an apparent uniform caliber, perceptible convex curvature lengthways, and smooth interior surface, being selected for the purpose; and after the alcohol or the ether is enclosed in sufficient quantity to form a suitable bubble, the ends are hermetically sealed. Now it is evident that if there be any irregularities in the arc against which the bubble runs, they will be imparted to the bubble—one end of which will be broader or narrower than the other, and shorter or longer from the zero-point; and in proportion to the irregularities will the ends of the bubble be unequally distant from that point, and will the tangent thereto deviate from horizontality.

Should the bore of the tube be uneven or irregular curvatures, or should the parts on each side of the zero-point not be symmetrical, the ends of the bubble, as they augment or diminish in length by changes of temperature, would not rest exactly equidistant from the zero-point, or mark equal divisions on the scales. The tangent, however, to the zero-point would be horizontal, although the bubble would have an apparent inclination; and therefore, to bring the ends of the bubble to coincide with the equi-distant divisions of the scales, would be to give the tangent an inclination, and throw the instrument out of adjustment. This results more or less with all unground or defective tubes, and consequently sections plotted, estimates made of work, and works set out and regulated from levels taken or given by such tubes, must be in error in proportion to their imperfection.

In levels of precision, especially those employed for astronomical and engineering purposes, the interior surfaces are made truly even and cylindrical, and with a sensible curvature upwards exactly to an arc of a circle, by grinding them with emery-powder and oil or water on steel cylinders, and then polishing them. This process is repeated until the bubbles prove, by turning the tubes end for end on a delicately-adjusted support, to be perfectly symmetrical, or until the ends appear at, or mark precisely equal distances from the middle or zero-point, the tangent to which is then horizontal.

Hence, in the preparation of these tubes the chief objects to be attained are, uniformity of bore, perfection of curvature, and smoothness of surface; and it should be observed, in conclusion, that whatever care and finish are bestowed on the exterior mountings of the tube, if the interior of the tube itself be imperfect in the above respects, the tangent given by the bubble will not be horizontal. Tubes have been and can be made to indicate a point half a second of a degree from exact horizontality, or within one-hundredth of a foot of horizontality at the distance of one mile. This slight deviation is due, not to the principle of the instrument, but to mechanical defects, from which no instrument, however delicately made, is absolutely free.

MANUFACTURE OF STEEL.

DISCUSSION BEFORE THE SOCIETY OF CIVIL ENGINEERS OF FRANCE.

Translated from "Le Génie Industriel."

An interesting paper upon this subject was presented by M. Galy Cazalat, of which the following is an abstract. This gentleman stated, that in 1851 he made public a process for making, without cost, gases for lighting and heating by causing a jet of steam to pass through a bath of liquid cast iron. This jet produced simultaneously hydrogen gas and steel, the increased value of the latter compensating the cost of producing the gas. He then demonstrated that a jet of saturated steam, alone, could convert, in three or four hours, not more than 200 kilogrammes of steel, which would be heterogeneous and solid. To obtain steel homogeneous and in a liquid state, he conceived, in 1855, the idea of passing simultaneously several currents of compressed air and of superheated steam through several tons of liquid cast iron, which, in less than 30 minutes, would be converted into liquid steel, ready to be poured into molds. After experimenting four years, and having failed to obtain authority to lay down pipes, he was obliged to forego the collection of hydrogen gas.

In 1856, Mr. Martin, of New Jersey, claimed the discovery of a new method of manufacturing steel. His method consisted in permitting melted iron to fall in a fine shower into a deep vessel, through which air was forced. The air rapidly decarburized the small pellets, or threads of iron, converting them into steel, or more frequently into liquid pure iron. To make steel, Mr. Martin added to this product a certain quantity of specular cast iron, thus restoring the requisite carbon.

In 1856, Bessemer presented a method of making wrought iron and steel by passing air or steam through a bath of not exceeding 200 kilogrammes of cast iron.

M. Galy Cazalat showed that, when a jet of ordinary steam is passed through the bath of iron, it will produce only a mass of heterogeneous steel, and will solidify it. The same result will follow when a jet of air is passed through a single pipe, entering any point of a bath of about 200 kilogrammes of cast iron. Indeed, the column of air passing through the liquid metal can be decomposed only at its circumference: the temperature of the metal is raised only by the .21 of oxygen, furnished by the decomposed air, while it is reduced by .79 of nitrogen, to which should be added the volume of air not decomposed. Furthermore, the air cannot touch the more distant molecules of iron, and hence its oxygen cannot burn the carbon they contain. Thus, when the mass solidifies, it is only a mixture of cast iron and steel.

M. Galy Cazalat remarked that it was not until 1861, that Bessemer succeeded in producing the steel now used in the forges.

Comment was made upon this communication by M. Jordan. He thought it might be divided into two heads: 1st. An examination of the antecedents and similitudes of the processes of Galy Cazalat, Martin and Bessemer. 2d. A description of a process for refining iron by steam.

As to the first head, M. Jordan had not studied the patents of M. Galy Cazalat; but he was familiar with his investigations, and desired to render full justice to the ingenuity and perseverance, of which they gave proof. But he believed that M. Galy Cazalat was not accurately informed as to the antecedents of the Bessemer process, which had no relation whatever to refining by steam. It is true that Mr. Bessemer, in 1855, in the first of his patents on the process which bears his name, declared his invention to consist in the injection of threads of air, or of steam, or of air and steam, into the midst, and among the particles of a mass of liquid, crude cast iron, &c.; but in this same patent he asserts, that the injection of steam, having the difficulty of cooling the bath, can be employed only at the commencement of the process, and that the decarburization must be completed by the use of air. M. Jordan is of the opinion that we should not look merely at the specifications of patents to find the history of the phases of an invention which has reached the practical stage, since inventors, to protect their rights, often introduce into them variations altogether untried. It would be far better to study facts. In the famous memoir, read before the British Association, in 1856, which produced a profound sensation among the English metallurgists, refining by steam was not even discussed. Bessemer was well acquainted with the fruitless experiments of Nasmyth, and that distinguished mechanic, who was present at the session, publicly approved the system of refining by air. Neither in the public experiments at Baxter house, in 1856, nor in those at the shops of the Great Northern Railway, was the question of refining by steam raised at all. In truth, there had been no particular effort made in that direction. The difficulties which caused M. Bessemer's works to be withdrawn for a time from public notice, lay in the selection of suitable irons and refractory materials, and, to a slight extent, in the arrangement of the apparatus. The almost immediate success obtained in Sweden, in 1859, in the establishment of Edsken, encouraged Bessemer to persist in his labors, in spite of the contrary opinions of a great majority of English forge masters. The theory of the process, at that time very obscure, began to engage the attention of various Swedish and German metallurgists, and soon it became known how to select coke irons suitable for it, then to recarburize the metal, and at the same time purify it by the addition of spiegeleisen. Success was achieved at Sheffield and at St. Laurin with gray hematite iron from Cumberland. As soon as success had been met with in Sweden, Mr. Bessemer made a communication to the civil engineers of London, and submitted to them many specimens.

However gratifying it might be to national pride, M. Jordan could not agree with M. Galy Cazalat in the assertion that it was by means of the money advanced by the French government to MM. Jackson & Co., that the Bessemer process had become what it now is. MM. Jackson had surely contributed to the perfection of the process; but it must not be forgotten that Mr. Bessemer and his family had expended a fortune of 400,000 francs, before he had reached success, and that MM. Brown & Co., of Sheffield, were manufacturing, with facility, large masses of Bessemer steel, when the process had scarcely been heard of in France.

M. Jordan also believed that M. Galy Cazalat had not been accurately informed, when he attributed to Martin the idea of using specular iron as a recarburizer. The importance of the functions of the carburet of iron and manganese had been pointed out by Heath, in 1839, and the use of specular iron had been announced by Mushet, in 1856. Martin's patents say nothing about it. The cast irons (necessarily gray irons), required by the Bessemer process must contain (under penalty of certain failure), but a slight proportion of manganese. Indeed, they should never contain more than 1 or 1.5 per cent. They should contain 2 to 2.5 per cent of silicium, which is a powerful conservator of heat. The Bessemer irons, manufactured from Algerian ores, contain but little manganese, and the Motka ores contain only 1 to 1.5 per cent. It is erroneous, therefore, to attribute to this metal the success of the Bessemer process, which is due, rather, to the presence of considerable proportions of silicium and carbon, to the absence of notable quantities of manganese, and the almost total absence of phosphorus.

M. Jordan states, that he has not the honor of Mr. Bessemer's personal acquaintance, and that he makes these statements solely in the interest of historic truth.

As to refining by steam, he states that its invention goes back as far as 1855. M. Guineveau, professor of metallurgy in the School of Mines, spoke, some thirty years ago, of a method of refining by steam. In 1840, Mr. Guest, proprietor of the Dowlais establishment, conceived of the injection of steam into the metal of the finery fire. In 1854, Mr. Nasmyth introduced steam into the bath of metal in the puddling furnace, by means of a recurved, hollow rabble. The steam was intended to stir the metal, and being brought into contact with the hot iron, to decompose, furnishing oxygen: this combining with the carbon, sulphur and other oxidizable elements, would eliminate them, while the hydrogen set at liberty would still further desulphurize the mass. The Nasmyth process has been subjected to prolonged trial, and finally abandoned, because the steam reduced the temperature of the bath. The process of M. Galy Cazalat is substantially the same as those of MM. Guest and Nasmyth. M. Jordan was unable to see how, by the use of steam, it was possible to arrive at the production of cast steel. According to the theory, which, it is true, is not definitely settled, as to what is the true reaction at the enormous temperature of the Bessemer process, the metal cannot be decarburized without the formation of much oxide of iron, and yet maintain the exalted temperature necessary to melt the steel. Water, it is true, contains for equal weights, much more oxygen than air. But its decomposition requires the expenditure of a large quantity of heat, which is not re-supplied; and although it may at first manifest its activity at certain points, if the iron is very siliceous, yet the general temperature of the bath is diminished, and the result is, not cast steel, but a mixture of cast, wrought and steely, iron and oxide. This now is the result of M. Jordan's attempts. The great advantage of air is, that it supplies oxygen, without absorbing heat for decomposition. It is probably better even than pure oxygen, of which the reactions would be too violent.

M. Galy Cazalat replied, that Mr. Nasmyth, the inventor of the steam hammer, was opposed to Bessemer in the Society of Civil Engineers of London.

Some metallurgists have asserted, and rightly, that since the invention of the reverberatory furnace, all puddlers are well aware, that the surface of the metal is decarburized by the oxygen of either air or steam: that the new process for making steel consists in causing the air or steam to pass *through* the metal, and this Nasmyth was the first to do—at least with steam. The partizans of the Bessemer process would assert, that the Nasmyth process was intended merely to render less laborious the mixing of the metal by the puddler, who moves about the hearth of the furnace a hollow rabble, through the end of which the steam issues, while the Bessemer process does away with puddling altogether, substituting for it the action of compressed air or saturated steam. M. Galy Cazalat showed that he first conceived the idea of passing steam through baths of zinc, lead and cast iron, in order to produce *without cost* hydrogen gas, through the increased value of oxide of zinc and lead, and especially of steel. He remarked further that nine kilogrammes of steam, which contain, as is well known, 630 calories per kil. bring into the bath 5670 calories. Consequently, their decomposition should absorb $34400 - 5670 = 28730$ units of heat. On the other hand, calculating the effect produced by the 8 kil. of oxygen resulting from the decomposition, and which should combine with the carbon contained in the iron, it will be seen that a kil. of carbon requires, in order to be burned, 2.5 kil. of oxygen, which disengages, in round numbers, 8000 calories, and 8 kil. of oxygen ought to burn $\frac{8}{2.5} = 3.2$ kil. of carbon, disengaging 25000 calories. It follows then, that for 9 kil. of steam, there would be a reduction in heat of 4730 calories; a result directly contrary to all experience, which shows that during the first ten minutes of its flow, the steam raises the temperature of the bath from a red heat, which is 1000°, to the brilliant white, which is 1500°. This false theory, which seems to be stereotyped in the minds of our most accomplished metallurgists, has occasioned, in the last ten years, a loss of several millions to our principal forge masters. He thinks it is about time to correct it by the true theory, founded upon experience, and upon the following chemical and physical principles :

1st. The surface of the bath of iron is decarburized by the contact of an oxide of iron.

2d. A kil. of oxygen, combining with the iron [Fe O], develops 5000 calories.

3d. Cast irons, for conversion into steel, contain about 5 per cent of combined or alloyed carbon.

When superheated steam passes through a bath of iron, it is decomposed into 8 parts of oxygen and 1 part of hydrogen: each kil. of oxygen uniting with the iron, produces 5000 calories. The 9 kil. of steam, therefore, develop 40000 calories, while its decomposition absorbs only 28730 calories. The increment of heat, therefore, is measured by the difference, 11270 calories, which are capable of raising a kil. of iron $11270 \times 3.6 = 40572°$, or 1000 kil. of iron about 40°. Protoxide of iron, containing 8 kil. of oxygen, when brought into contact with the free carbon of the iron, will burn 3.5 kil. of carbon, producing 28000 calories: bearing in mind that, at the extreme temperatures of the process, the heat tends to separate the oxygen from the iron, it must be admitted that the cooling due to this separation, is much less than the heating, measured by 28000 calories.

M. Brull remarked, that he had followed the first experiments of M. Galy Cazalat, at the Imperial foundry at Ruelle, and had had occasion to make a calculation of the number of calorics removed from the bath of cast iron, by the various decompositions, and developed by the combinations, and the calculation, based upon the analysis of the irons employed, had given generally a gain in heat. Moreover, the experiments, notwithstanding divers defects in the details of the plant, which interfered with the success of the operation, yet enabled him to determine that the bath of metal would not cool, but would remain liquid, after the passage of a current of superheated steam. Later experiments have confirmed this result, but have not yielded a constant quality of steel. M. Brull stated that the order of the various phenomena of decomposition and combination of oxides did not affect the final results. It would be sufficient, in estimating the heat developed, to consider merely the various elements in the iron which are burned, and separate from the metal in the form of silicates, without introducing any hypotheses as to the precise manner in which the definite compounds are formed.

M. Depretz remarked that the 34000 calories, developed by the combination of 8 kil. of oxygen and 1 kil. of hydrogen, involved the assumption that the products of combustion be reduced to the zero of temperature. In the experiments cited by M. Galy Cazalat, the steam to be decomposed was under a pressure of two atmospheres, and at the temperature of 600°; each kil., therefore, contained a quantity of heat, which, according to the empirical formulæ of M. Regnault, would be $606.5 + .305 \times 120 + (600 - 120) \times .48 = 873$ calories. The quantity of heat contained in 9 kil. of steam would then be $873 \times 9 = 7857$ calories. To decompose these 9 kil. of water, would therefore take $34000 - 7857 = 26543$ calories, which require for each kil. of oxygen $26543 \div 8 = 3318$ calories. According to the experiments of M. Depretz, upon the oxidation of iron, each kil. of oxygen develops 5325 calories. There is, then, a clear gain of heat equal to $5325 - 3318 = 2007$ (say 2000) calories for each kil. of oxygen.

M. Lencauchez, commenting upon the ideas of M. Galy Cazalat, thought, contrary to the generally received opinion, that the injection of steam into the bath of iron, at a temperature of 10 to 20° above the vaporizing point corresponding to a given pressure, would not occasion a reduction of temperature, but on the contrary, an increase. The quantity of oxygen furnished to the bath being much greater than in the case of atmospheric air, the refining, or more properly the oxidation, of the metal would proceed with great rapidity. The liberated hydrogen could not, in so short a time, reduce the excess of oxide of iron, since the latter is diffused through a large mass of fused metal, which protects the molecule of oxide from the reducing action of the hydrogen. For a similar reason the hydrogen, which is in the nascent state, will not react upon the metalloids (sulphur, phosphorus, arsenic and silicium), which often do not exceed one per cent of the mass under treatment. If the injection of steam be prolonged, the oxide of iron will attack the lining of the vessel, forming multiple silicates, so that the product is neither iron nor steel.

In the following session of the Society, M. Galy Cazalat further stated, that the production of steel by superheated steam had, for ten years, been opposod by the false application of two principles. When 1 kil. of hydrogen combines with 8 kil. of oxygen, it produces water, with evolution of 34462 calories.

Reciprocally, the decomposition of 9 kil. of water into its elements occasions an absorption of 34462 calories.

The conclusion has been, that the decomposition of steam cools the bath which it traverses. But we must account for the union of oxygen with carbon, which restores 25000 calories—a quantity insufficient, it is said, to make steel. He asserts, however, that experience does not confirm this reasoning, but that if a current of dry steam be passed through cast iron at 1200°, it soon raises it to a dazzling white heat. The true theory he asserts to be as follows: Oxygen has a greater affinity for iron than for carbon. Since crude iron contains sixteen times as much iron as carbon, it is with the iron that the oxygen combines, producing a much greater heat than would be the case with atmospheric air, which contains, for equal weights, only one-fourth as much oxygen as water. M. Galy Cazalat enumerated the patents he had received, from 1855 to 1858, for decarburizing cast iron by currents of superheated steam. To obtain a constant production of steel, the iron is first oxidized, then is partially recarburized by the addition of specular iron in crucibles, placed upon the hearth of a reverberatory furnace. In pouring large masses of steel blow-holes would be developed, which it was necessary to reduce under the hammer. He also indicated a method of compressing cast steel in the mold by closing it with a metallic cap, and exploding powder (without sulphur), which was introduced by means of a tube. Long afterwards, Mr. Whitworth conceived the idea of compressing steel by hydrostatic power; but the cannon so made burst, and exhibited blow-holes in all the surfaces of fracture.

He also gave some details for manufacturing, simultaneously, iron and steel, by means of certain minerals contained in volcanic sand from Reunion, Naples and New Zealand. This is a titaniferous, manganic, sesquioxide of iron, containing 80 per cent of oxide of iron, 10 to 12 per cent of titanic acid, and 6 per cent of silica, alumina and lime, and has long been deemed infusible. 50 kil. of this mineral, placed in a graphite crucible has yielded 27 kil. of steel, of which M. Galy Cazalat presented specimens which had been recognized as superior to steels, costing 1,500 francs per ton. The ore is costly by reason of the difficulty of separation from the sands which contain it in small proportions. The separation is effected by crude washing, which yields a sand containing 20 per cent of ore, after the first washing, and 60 per cent after 5 or 6 washings. It is still further eliminated by magnets, until it reaches 80 per cent. M. Galy Cazalat had succeeded in obtaining this ore quite pure, and purposes treating it in a reverberatory furnace, through the roof of which are ten openings, arranged in two lines. By these openings the charge of pig iron is introduced, and when this is melted, plate iron tubes are let down through the openings into the melted bath. These tubes are closed at the lower ends, and coated with an extremely refractory ganister. They are charged with titaniferous ore, which does not melt at the temperature of the furnace, but if a current of air and dry steam be passed into the melted bath, they will agitate it, and give rise to an intense combustion, resulting in an enormous temperature, which melts the ore in the crucible tubes, converting it into a clear, limpid steel, as free from air holes as Krupp's crucible steel. Thus are produced at once, steel in the crucibles, and wrought iron in the furnace, and the operation may be repeated and continued indefinitely.

M. Lencauchez thought the assertions of M. Galy Cazalat were exaggerated. He doubted the ameliorating influence of titanium, and did not think the specimens remarkable. He did not think the proposed apparatus would withstand a series of operations involving such enormous temperatures as M. Galy Cazalat spoke of.

As to the systematic use of powder for reducing blow-holes, he thought it scarcely practicable, and much inferior to the hydrostatic press working at 600 atmospheres. Porous steels are steels poorly made. By using bases which can absorb the oxide of iron produced in the bath, we may escape the reaction of the latter upon the remaining carbon, and thus, the formation of cavities of carbonic oxide. The use of fluxes seemed to him a simple and certain method of obtaining steel free from air holes.

M. Jordan thought it might be advisable, in following up the discussion, commenced at the previous session, upon the communication of M. Galy Cazalat, to explain thoroughly the theory of heating baths of cast iron by intermolecular combustion, in certain systems of refining, and to correct the erroneous opinions which had been disseminated with reference to refining by steam. He also regarded it as his duty to defend the French forgemasters from the charge of having wasted millions of money by adherence to a false theory. He would not revert to the historical questions raised at the last session, and he had spoken of them only because Mr. Bessemer was not represented, and because he believed himself well acquainted with their history, from having studied them conscientiously and impartially. He then read a note upon refining by air, steam and oxygen, treating of the processes respectively of Bessemer, Galy Cazalat and Heaton.

1. With reference to steam.

Assuming that a bath of 1000 kil. of melted gray iron is at the temperature of 1400°, containing* 1000 $(1200\times .17+46+200\times .21)=293000$ calories: it will require 210 calories to produce a variation in temperature of 1°, and the loss of 42000 calories will reduce the iron to the temperature of fusion.

Let us examine successively the combustion of iron, of the carbon, and of the silicium.

Combustion of the iron.—For each centième (10 kil.) of iron burned, there will be required $\frac{10}{3.5}=2.875$ kil. of oxygen, which will produce 12.857 kil. of oxide of iron, developing, according to Dulong, $2.857\times 4327=12362$ calories. The oxide of iron formed, of which the capacity for heat (.17) is very considerably greater than that of wrought iron (.11) will absorb, in order to take the temperature of the bath, at least $(12.857\times .17-10\times .11)\ 1400=1520$ calories.

There will then remain, of available heat from the combustion of the iron, only 10840 calories.

But, to obtain 2.857 kil. of oxygen, there will be necessary 3.214 kil. of vapor of water, containing .357 kil. of hydrogen. This steam, assumed to be dry at 100°, will absorb, in decomposition, $29512\times .357=10538$ calories, and the hydrogen being eliminated after being heated to 1300°, will carry away $.357\times 3.40\times 1300=1578$ calories, making the total loss 12116 calories. The gain in heat being, as above, 10840 calories, it is clear that the bath will ultimately lose 1276 calories for each centième of iron burned by the steam. This loss cannot be re-supplied by superheating the 3.214 kil. of steam, since it would be necessary (the capacity for heat of the steam being .475) to raise it to about 850°, and M. Jordan does not believe that steam can be practically heated beyond 600°.

The combustion of the manganese gives the same results as that of iron.

Combustion of the carbon.—For each 10 kil. of carbon there would be required 13.333 kil. of oxygen to produce 23.333 kil. of carbonic oxide. The combustion may be direct or indirect, that is, effected by the intervention of oxide of iron; but, as Mr. Brull remarked, the quantity of heat developed will always be that due to the formation of carbonic oxide. The result of this combustion will be $10\times 2473=24730$ calories, and the oxide of carbon resulting from 10 kil. of carbon heated to 1400°, will absorb, in elimination, a quantity of heat equal to $(23.333\times .2479-10\times .241)\ 1400=4718$ calories. The gain of heat to the bath will be only $24730-4718=20012$ calories.

To obtain 13.333 kil. of oxygen, there will be required 15 kil. of steam and 1.667 kil. of hydrogen; the decomposition of the former absorbing $1.667\times 29512=.49187$ cal., and the eliminated hydrogen carrying off $1.667\times 3.40\times 1300=7367$ calories. The total loss, therefore, will be $49187+7367=56554$ calories. Hence, the actual loss to the bath will be $56554-20012=36542$ calories.

Combustion of silicium.—For each 10 kil. of silicium there will be required $10\times\frac{25}{21.5}=11.16$ kil. of oxygen, which will form 21.16 kil. of silicic acid, developing 80000 calories, if we admit that the calorific power of sili-

* The temperatures of fusion of various kinds of cast iron are: white iron 1050° C.; graphitic gray iron 1200° C.; gray manganiferous iron 1250° C. The specific heats (capacity for heat):

Wrought iron between 0 and 100°	.109
" " " 0 and 350°	.125
Cast iron, white, slightly carburized	.127
" " " much "	.129
" " gray, between 0 and 200°	.130
" " " " 0 and 1000°	.170
" " " liquid	.210

The latent heat of fusion of ordinary gray iron is 46 calories.

cium is equal to that of carbon completely burned. Silicia acid, by reason of its capacity for heat differing from that of silicium, will absorb a quantity of heat about necessary to bring the 11.16 kil. of oxygen to the temperature of the bath; that is to say, $11.16 \times .218 \times 1300 = 3160$ calories. The bath will then gain 76840 calories. To obtain 11.16 kil. of oxygen will require 12.555 kil. of steam, setting at liberty 1.395 kil. of hydrogen: the heat absorbed by the decomposition being $1.395 \times 29512 = 41169$ cal, and that carried off by the hydrogen $1.395 \times 3.40 \times 1300 = 6166$ calories, the total loss to the bath will be 47335 calories. The total gain, therefore, is 76840—47335 = 29505 calories.

Refining by steam.—Let us now apply the foregoing data to a bath of 1000 kil. of cast iron, of which we will suppose the composition to be similar to that of one of the good Bessemer irons fabricated at the establishments of Terrenoire St. Louis, Givors, &c.

1000 kil. will contain 42.50 kil. of carbon, 20 kil. of silicium, 937.50 kil. of iron and manganese. Suppose the operation to be the regular practice, viz: completely decarburizing, and partially recarburizing. The loss being 15 per cent, we shall obtain 850 kil. of pure iron by burning 87.50 kil. of iron and manganese. Introducing the steam in minutely divided jets, cut off from all extraneous sources of heat, and thoroughly dry, the gains and losses will be:

	Centièmes.	Gain.	Loss.
Silicium	2	59010	......
Carbon	4.25	.....	155303
Iron	8.75	.....	11165
Totals	....	59010	166468
Net loss			107458

The capacity for heat of cast iron being about .16, it will be seen that the temperature of the bath would be reduced more than 650°, without taking into account the exterior cooling of the vessel. The result would be only a mass of pasty iron commingled with oxide and silicate of iron. It is true, that the figures, 107458 calories, above given, are somewhat exaggerated, because the hydrogen and carbonic oxide issuing from the bath are probably at a lower temperature than 1400°; but it will be seen that, assuming this gas to issue at 500° to 600°, the loss of heat will still be more than 60000 calories, and that without accounting for the exterior cooling of the converter, which exercises an important effect.

When an operation of this kind is observed, there will be noted, at first, an increase of temperature, due to the combustion of the silicium, which takes place first: but the commencement of the decarburization reduces the temperature to such a degree that the molecules of the mass lose much of their mobility, the subsequent reactions work badly, and the refining is not completed in a homogeneous manner throughout the mass. Furthermore, in spite of all precautions, an excess of steam will inevitably be introduced, which adds greatly to the rapidity of the cooling. Refining by steam cannot succeed with Bessemer irons any better than with ordinary steel irons (those containing manganese highly carburized and slightly silicized). To avoid a reduction of the theoretic temperature, always less than the real reduction, there is required a cast iron with little carbon, and much silicium; for example, 4 per cent of the latter, and 2 to 3 per cent of the former. But such irons are very exceptional, resulting from a very dry process, which a furnace cannot maintain with impunity. Moreover, as they can be obtained only from ores relatively poor, such as those of the secondary and tertiary formations, they will always contain more or less phosphorus.

It will now be understood why the great establishment of Dowlais, in Wales, after experimenting several months with steam refining, both in the finery fire and puddling furnace, has given it up, notwithstanding the hopes and anticipations of Mr. Guest. Mr. Truran, the engineer of this establishment, asserts that the injection of steam cools the bath. Mr. Nasmyth, the distinguished mechanic, has arrived at the same conclusion. Mr. Percy, professor of metallurgy in the School of Mines at London, who was acquainted with the experiments at Dowlais, and with those of Nasmyth and Parry, also declares that steam will not raise the temperature of the bath. The fruitless attempts in France during the last twelve years have shown nothing contrary to the results previously obtained in England. It has been hoped that, in steam refining, the hydrogen might be utilized in purifying the metal from sulphur and phosphorus. M. Jordan was unaware of any authentic experiments or analyses serving to show that such was the case. He much doubted the efficiency of hydrogen to remove these elements disseminated in small quantities throughout the entire mass. A current of hydrogen passed through a porcelain tube, over sulphur, at a high temperature, is far from converting it completely into sulphydric acid, and if the latter is passed over red-hot iron it parts with the sulphur, as is well known. The affinity of hydrogen for phosphorus is not great.

M. Jordan concluded his remarks by stating, that refining by steam is much inferior to refining by the pneumatic process for the purpose of making steel. He remarked upon the importance of the function of silicium. This is the all-essential element of combustion. Steel makers classify their irons into "cold" and "hot" irons, according as they contain little or much of it. He presented two specimens of iron to the Society; one a gray Bessemer iron—the "hot" variety, containing 2 to 3 per cent of silicium, recognizable by its gray starry grain, smelted at the St. Louis furnaces near Marseilles, for the Imphy Steel Works; the other a specular variety, or spiegeleisen, containing 8 to 10 per cent of manganese, essentially a "cold" iron, easily recognizable by its large crystalline facets, and made at the same furnaces for the steel works on the Loire.

SURMOUNTING RAILWAY INCLINES.

From the "Building News."

To be obliged to start a heavy train upon a stiff incline, in damp weather, when the rails are slippery, or what is technically known as "greasy," is a task hated of engine drivers. If possible, they invariably back on to the level, so as to get a bit of a run at the gradient. In fact, to employ a homely simile, there is exactly the same difference in the two instances referred to as in a man's taking a "standing" and a "running" jump. If the inclines on railways could be so arranged that every ascending gradient should be preceded by a descending one, in other words that the two should meet at the lower level, the impetus acquired in the descent would materially assist the subsequent ascent. There are undoubtedly some instances where this desirable result obtains, but they are, in all probability, occasioned more by accident or necessity than by design. The steeper the incline the greater must be the adhesion of the wheels on the rails. Hence the innumerable patents and inventions for accomplishing this purpose, which climaxed in the introduction of the middle rail and extra wheels. In one sense weight and adhesion are synonymous terms, but to gain the necessary amount of adhesion by simply increasing the weight, would be to employ a remedy worse than the evil, as the difficulty is to get the weight itself up the hill. The experiments at Mont Cenis have quite thrown into the shade anything that has been done at home in the way of surmounting inclines, although we have in latter days distinguished ourselves in the art of making steep railway gradients to a degree that would have appalled our predecessors in that particular branch of engineering. A trial is to be made on the French side of Mont Cenis of the system of an Italian engineer, M. Agudio, for working sharp inclines on mountain summits. This principle has been employed for some years upon the Turin and Gênes Railway, and the experience gained during its application there has enabled the inventor to remedy the imperfections, correct the errors, and introduce those modifications and improvements which are indispensable to the success of every newly-tried mechanical invention.

Steep gradients are essential to the system of M. Agudio. He reconciles the differences of level by inclines of 1 in 10, and presses into his service the resources that nature has placed at his disposal, instead of employing means wholly artificial for accomplishing his purpose. The natural forces or motive power to be found in mountainous districts is utilized by hydraulic machines placed one at the summit, and the other at the bottom of the incline. From these the power is transmitted by the agency of steel telodynamical cables, working at a high velocity, to a locomotive, or, rather, locomotor, which is placed at the head of the train. As no boiler is required, the weight is very small in comparison with that of an ordinary locomotive, being restricted solely to that necessary to provide for the moving parts. At the same time, a certain amount of adhesion is absolutely indispensable, especially on inclines of the steepness already mentioned. In order to effect this, there is, first of all, the weight of the engine. Secondly, this weight is rendered more serviceable by being carried on eight wheels; and, thirdly, there are six horizontal wheels introduced, which by means of springs are caused to press against a central rail, similarly to the well-known Fell system. Powerful brakes are supplied to guard against contingencies in descending the inclines. A grant has been made by the Imperial Government of nearly £10,000 for carrying out this principle at

Mont Cenis, and a similar subvention of the same amount has been given by the Italian Government. The particular section of the Mont Cenis Railway to which this system is to be applied commences at Lanslebourg, a station on the Fell road, crosses the river Arcq, and ascends the sides of the hill by nearly the same route as that occupied by the lines of telegraph. A succession of sharp curves from 450 ft. to 900 ft. radii, and an equal number of heavy gradients, bring the new section to the summit, where it rejoins the line of Fell. This route has been adopted by M. Agudio in order to demonstrate the great advantage of his system over others in use in similar arduous localities. The total difference of level between the starting point and the summit level is 2,296 ft., and this is accomplished in a distance of 2.2 miles, whereas 7.5 miles is the distance required by Mr. Fell to rise the same height. The length of line, and *cæteris paribus*, the cost is, therefore, in the latter instance, about three and a-half times that in the former. One of Fontaine's turbines constitutes the prime motor. It is fed by the waters of the Arcq, which are collected and stored in a reservoir containing 900,000 gallons of that fluid, the whole of which is capable of being run off and replenished six times a day, thus affording six ascents and six descents in the twenty-four hours. Each ascent will occupy about a quarter of an hour, and will of course be made without any interruption *en route*. The load taken up will in round numbers equal sixty tons. It is stated that the Fell locomotive requires an hour to perform the same journey, that is, so far as the difference of level is concerned, and conveys only one-fourth of the load between the same termini. M. Agudio calculates that the ordinary passenger trains, which will weigh considerably less than sixty tons, will "do" the journey in ten minutes. At the present day, when engineers have exchanged the old principle of adapting the road to the locomotive for the more modern practice of suiting the locomotive to the road, any proposed improvement in that direction is deserving of careful and impartial consideration. We trust, in another article, to record the result, and we hope, the success of the proposed experimental line.

STEEL MANUFACTURE.—The discussion before the French Society of Civil Engineers will be read with interest.

ON THE SELECTION OF BUILDING STONES, AND THE CAUSES OF THEIR DECAY.—In the selection of building stones for the exterior walls of a building, *color*, *texture* and *durability* are the objects of the first importance; and all of these ought to be combined to render the structure perfect. Too little attention has been given to the subject of building stones; and while on the one hand we are largely using a brown stone, which gives a sombre, cheerless aspect to the structure, the opposite extreme has been sought in the white marble, or that which is more nearly white in color. In contrast with these, we have the red, glaring color of brick; and it is only partially that this offensive aspect is palliated by painting of neutral tints. In a few eastern cities and towns we find the light gray granites now used in preference to the brown freestone, the white marble, or the dark granite which have been much in use in past years.

No one can fail to experience the sensation of relief afforded by the structures of light colored granites in the city of Boston, or those of the buff or dove colored limestone in the city of Chicago, or of the light gray freestone of many buildings in Cleveland and other places, and of the buff colored brick of Milwaukee. In these cases we have not the excessive reflection of light, or the glare which comes from white buildings, whether of marble or of painted brick, nor the sombre cheerless expression of the darker stone, caused by its great absorption of light. It is only necessary to consider the effects produced by the structures of these different materials upon one's own sensations, in order to determine what are the most agreeable tints, or those which please the eye and produce a cheerful impression upon the mind.

In the majority of structures the necessities of locality, cheapness, or other causes, compel the erection of structures from materials most accessible; but these considerations are not imperative in the case of an important public building.

In many cases where the rock is homogeneous throughout, and the color uniform and satisfactory, it is only to be inquired whether the coloring material is such as will produce decay or disintegration of the particles. When the general color is produced by the aggregation of different materials of distinct coloration, the character of each one is to be considered, and its effect upon the whole; and it is important to have such material comparatively fine-grained, and the different parts as uniformly mingled together as possible. As a general rule, it is only in the darker stones that the coloring matter has any tendency to disintegrate the mass.

In the selection of building stones, the simple presentation of a sample is not enough. The rock in place should be examined in the outset; for in its natural outcrops it has been exposed to the action of the weather, in all its influences, for many thousands of years. One of the principles taught in elementary geology is that the soft and decomposing rocks appear in low rounded or flattened exposures, or entirely covered by the soil or their own debris, forming no conspicuous feature in the country; while on the contrary the harder rocks stand out in relief, producing marked and distinguishing features in the landscape. It not unfrequently happens that the geologist having familiarized himself with the succession and character of the rocks of a particular locality or neighborhood, by seizing the features and character of the prominent beds, is able to trace them in succession along the escarpment or mountain range as far as the eye can reach, and to approach them from any distant point with assurance that he has not been deceived.

The strata which make these features in the landscape are the ever enduring rocks, which have withstood the action of the atmosphere through a period a thousand times longer than any structure of human origin. One cannot doubt that if properly placed in any artificial structure, they would still withstand the action of the elements. These escarpments, in their natural situation, may be coarse, rough and forbidding, more or less dilapidated or unequally dilapidated from the effects of time; but as they there present themselves, we shall be able to see their future in any structure exposed to the same influences.

It is true, however, that no artificial structure or position will ever subject the stone to the same degree of weathering influence to which it is exposed in its natural position, but the same changes in degree will supervene upon any freshly exposed surfaces. In its natural position the bed has been encased in ice, washed by currents, saturated with rains and melting snows, frozen and thawed, and exposed to the extreme of summer heat without mitigation. The rock which has withstood these influences is quite equal to withstand the exposures of a few centuries in an artificial structure. Yet there are occasionally modifying influences and conditions which have sometimes subdued the permanence of a durable stone, and given preference to others less durable. It therefore becomes necessary to carefully examine all these conditions, and to determine not only from the rock in place, but also from its physical constitution, whether it will meet the requirements of the structures proposed.

It not unfrequently happens, in working a quarry, that layers are reached which have not been exposed to the weather, and it is then necessary to test the strength and power of endurance of the stone. This may be done by repeated exposure to freezing and thawing, by testing the strength or power of resistance to pressure, etc. The exposure to freezing and thawing will not only determine its power of resisting the action of the weather, but will determine also whether such foreign ingredients as iron pyrites may exist in the mass. Chemical analysis may be resorted to, for the purpose of comparison with specimens of known composition and durability; but chemical analysis alone cannot determine, without other testing experiments, the strength or power of endurance of the stone.

In some countries, and in certain localities in our own country, the evidence obtained from ancient structures is available in determining the durability of the stone which has been used. Yet it would seem that this information has been of little avail in many places, where the rebuilding of edifices is repealed every century. Experience, in many cases, does not teach the lesson anticipated; and when a dilapidated structure is pointed out, the argument is made that "these stones were not well selected," or they were obtained "at the first opening of the quarry, and were not as good as now furnished." And again, as already remarked, there are few cases in which parties are permitted to select the material without prejudice, the influence of interest, or the absence of important information. Examples are everywhere before us of the improper selection of materials for buildings, and these examples do not deter from their use in the erection of others. When good material is abundant and accessible, it will be used; in other situations, comparatively few durable structures are likely to be erected.—*From Prof. James Hall's Report to the New York Capitol Commission.*

EXPERIMENTAL RESEARCHES ON THE MECHANICAL PROPERTIES OF STEEL.

A paper read before the British Association at Exeter, by WILLIAM FAIRBAIRN, L.L. D., F. R. S.

In my last report I had the honor of submitting to the Association an experimental inquiry into the mechanical properties of steel obtained from different sources of manufacture in the United Kingdom. On that occasion several important experiments were recorded from specimens obtained from the best makers, and bars were received from others, the experiments on which were incomplete at that time. Since then I have had an opportunity of visiting the important works at Barrow-in-Furness, and from these I have received bars and plates of different qualities for the purpose of experiment, and such as would admit of comparison with those recorded in my last report. I have also received specimens from Mr. Heaton for experiment, illustrations of the new process of conversion from crude pig iron—of different grades—to that of steel, as exhibited in the results contained in this report.

In every experimental research connected with metals it is necessary to ascertain as nearly as possible the properties of the ores, the quality of the material, and the processes by which it is proved. On most occasions this information is difficult to obtain, as in every new process of manufacture there is a natural inclination—where the parties are commercially interested—to keep it as long as possible to themselves, and hence the reluctance to furnish particulars.

Of this, however, I can make no complaint, as Mr. Bessenger, the Barrow Company, and Mr. Heaton have, unreservedly, not only opened their works, but they have furnished every particular required, including chemical analyses relative to the properties of the ores, and the processes by which they are reduced.

From this it will be seen that in some of the experiments, I have had the privilege of recording the chemical as well as the mechanical properties of the specimens, which have been forwarded for the purpose of experiments, and of ascertaining their respective and comparative values.

The proprietors of the Barrow Works have confined themselves to certain descriptions of manufacture on the Bessemer principle, these being chiefly steel plates, rails, tyres, and girders. From the nature of the ore and fuel, the latter of which is chiefly brought by rail from the coal fields of Northumberland and Durham, a description of highly refined homogeneous steel is produced, and as this manufacture is intended for purposes where tenacity and flexibility are required, it would not be just to compare it with other descriptions of manufacture where the object to be attained is hardness; such, for instance, as that employed for carriage springs and tools. The description of iron required for rails, beams, girders, &c., is of a different character; tenacity, combined with flexibility, is what is wanted, to which may be added the power to resist impact.

The same may be said of wheel tyres and other constructions where the strains are severe, and where the material is sufficiently ductile to prevent accidents from vibration, or those shocks and blows to which it may be subjected. Keeping these objects in view, the Barrow Company have, to a great extent, been limited to this description of manufacture; and judging from the ductility of the material as exhibited in the experiments, there is little chance of accidents from brittleness when subjected to severe transverse strains, or to the force of impact.

In calculating the value of the hematite steel we have been guided by the same formulæ as adopted for comparison with similar productions from other works. Very few of them, however, would admit of comparison, as no two of them appear to be alike. The hematite steel is manufactured at the Barrow Works for totally different purposes from those of other makers, and, having the command of a variety of ores for selection, as may be seen from the analysis of the ores, as well as the Tables, the desired quality of the steel can be obtained at pleasure.

We have therefore submitted the different specimens to the same tests as those received from other makers, not only for the purpose of ascertaining wherein their powers of resistance differ, but also wherein consists their superiority, as regards deflection, elongation, and compression, from all of which may be inferred the nature and properties of their different structures, and the uses to which they may be applied.

It is for this purpose we have applied the same formulæ of reduction to each particular experiment, as in the other cases, and the results have been embodied in the summaries.

As the Bessemer principle of manufacturing direct from the ore is calculated to produce great improvements and great changes in the production of refined iron and steel, and as the homogeneous properties of the material thus produced are of the very first importance as regards security, &c., it is essential to construction that we should be familiar with the mechanical properties of the material in every form and condition to which it may be employed.

For this purpose I have given all the various forms of strain, excepting torsion, which is of less moment, as the strains already described involve considerations which apply with some extent to that of torsion, and from which may be inferred the fitness of the material for the construction of shafts and other similar articles to which a twisting strain applies.

The great advantage to be derived from the Barrow manufacture of steel, to which we have referred, is its ductility combined with a tensile breaking strain of from 32 to 40 tons per square inch. With these qualities I am informed that the proprictors are able to meet the requirements of a demand to the extent of 1,000 to 1,200 tons of steel per week, which, added to a weekly produce of 4,500 tons of pig iron, enables us to form some idea of the extent of a manufacture destined in all probability to become one of the most important and one of the largest in Great Britain.

In this extended inquiry I have endeavored to deduce true and accurate results from the specimen with which I have been favored by the Barrow Company. In the same manner I have now to direct attention to the product of an entirely new system of manufacture, introduced by Mr. Heaton, of the Langley Mill, near Nottingham.

The experiments on this peculiar manufacture require a separate introductory notice, as the process of conversion is totally different to that of Bessemer, the puddling furnaces, or that of the old system of charcoal beds.

For the finest description of steel, the old process of conversion is still practiced at Sheffield, a fortnight to three weeks being required for the conversion of wrought iron into steel, and, with the exception of Mr. Siemens' reverberatory gas furnace, there had been no improvements made on it, until Mr. Bessemer first announced his invention, by means of which melted pig iron was at once converted into steel.

By the old process the metal was first deprived of its carbon and reduced to the malleable state, when it was rolled into bars and retained from fourteen to twenty-one days in charcoal beds, until it had absorbed, by cementation, the necessary quantity of carbon.

The new process of Mr. Heaton, unlike that either of Mr. Bessemer or cementation, simply deals with the pig iron, and, according to his own statement, eliminates the superfluous carbon, so that steel is in the first place produced, and thence wrought iron of a still further elimination of the carbon.

This is very different to the puddling or the Bessemer processes, of which the former was tedious and expensive, whilst in the latter the pig iron was rendered malleable without any additional fuel, and ready for the hammer or the rolls in a very short space of time.

In so important a branch of metallurgy it would be remarkable if Mr. Bessemer had hit upon the only feasible means of converting iron into steel. Other minds have been inspired in the same direction by Mr. Bessemer's success, and the admixture of metals to effect a transmutation, has been assumed in many forms and proportions, so as to increase our knowledge and lessen the cost of production.

Amongst these is the new process of Mr. Heaton, the detailed description of which is given in a pamphlet by Dr. Miller, a copy of which is annexed. In addition to Dr. Miller's statement, Mr. Robert Mallet reported on the subject, and expressed himself highly sasisfied with the results, both as regards the chemical and physical properties of the metal, and having been present at the experiments made at Mr. Kirkaldy's testing machine, he states the result as under:

	Rupturing strain in tons per sqr. inch of section.	Extension of rupture per cent. of original length
		per in.
Heaton's steel iron.	22.72	21.65
" cast steel.	41.73	7.20

The results recorded in the above Table for cast steel are somewhat below the results obtained in my own experiments, being in the ratio for breaking strain—44.94 : 41.73, or as 1 to .936 nearly.

The whole of these experiments appear to be correct, and assuming the statement of cost to be equally satisfactory, we arrive at the conclusion that, "taking steel from the furnace in ingots, or made into steel rails or bar iron, or in any other form or ordinary manufacture, the net cost of production, after adding 10 per cent for management, including all cost of labor, fuel, and material, and making all allowances for wear and tear, and the like, is *several pounds sterling per ton* under the present market prices of the several descriptions of the metal." And this will be sure to be a matter of surprise when it is taken into consideration that (to repeat the words of Mr. Mallet) "steel can be produced from coarse low-priced brands of crude pig irons, rich in phosphorus and sulphur; thus wrought iron and cast steel of very high quality have been produced from Cleveland and Northamptonshire pig irons rich in phosphorus and sulphur, and every ironmaster knows that first-class wrought iron has not previously been produced from pig iron from either of these districts, nor marketable steel at all. With these observations, I have now to refer to the drawings of the furnaces and apparatus, which I have attached in illustration as an appendix. In conclusion I may state that, looking at this new process, and its further development as a step in advance of that which has already been done by Bessemer and others, we may reasonably look forward to a new and important epoch in the history of metallurgic sciences.

Before entering upon the experiments, it will be necessary to repeat the formulæ of reduction as given in the previous report of 1867. This appears to be the more requisite, as it may be inconvenient to refer to the Transactions of 1867, where it was originally introduced.

Formulæ of Reduction.

For the Reduction of the Experiments on Transverse Strain.

When a bar is supported at the extremeties, and loaded in the middle.

$$E=\frac{w\,l^3}{4\,\delta\,K\,d^2} \quad . \quad . \quad . \quad . \quad . \quad (1).$$

where l is the distance between the supports, K the area of the section of the bar, d its depth, w the weight laid on, added to five-eights the weight of the bar, δ the corresponding deflection, and E the modulus of elasticity.

When the section of a bar is a square,

$$E=\frac{w\,l^3}{4\,\delta\,d^4} \quad . \quad . \quad . \quad . \quad . \quad (2).$$

These formulæ show that the deflection, taken within the elastic limit, for unity of

TABLE No. I. ANALYSES OF IRON ORES USED AT THE BARROW HEMATITE IRON AND STEEL COMPANY'S WORKS, BARROW-IN-FURNESS, LANCASHIRE.

	NAME.	Water.	Sesqui-oxide of Iron.	Iron.	Phosphoric Acid.	Phosphorus.	Sulphuric Acid.	Carbonic Acid.	Silicia.	Alumina.	Protoxide of Manganese.	Lime.	Magnesia.	Insoluble Residue.	Total.	Silicia.	Alumina.	Lime.	Magnesia.
1	Park ore (average)..........	1.91	76.77	53.74	0.04	0.02	none	none	0.14	0.04	0.63	0.24	trace	19.79	99.58	18.51	0.09	0.04	trace
2*	" (best rough)........	0.47	94.88	66.42	0.03	0.01	"	"	0.10	0.07	0.04	0.34	"	4.49	100.39	4.45	trace	trace	none
3*	" (" fine)..........	0.68	90.44	63.31	none	none	"	"	0.09	0.30	0.30	0.30	"	9.11	106.95	8.74	0.24	"	trace
4	Lindal Moor (blast, No. 1)...	2.02	78.61	55.03	0.03	0.01	0.04	trace	0.04	trace	0.24	0.57	0.19	18.31	100.05	16.11	1.67	0.03	0.05
5	" (" No. 2)...	1.61	76.05	53.24	0.04	0.02	trace	"	0.03	none	0.08	0.49	0.14	21.07	99.53	18.60	2.04	0.08	0.11
6	" (" No. 3)...	2.68	70.17	49.12	0.04	0.02	0.03	none	0.06	0.37	0.31	0.59	trace	25.24	99.49	22.24	2.48	0.24	0.16
7	" (common)......	10.84	65.21	45.65	0.03	0.01	trace	"	trace	0.24	0.01	0.41	0.14	22.38	100.26	18.67	3.42	0.05	0.04
8*	Lindal Cote (puddling, No. 1)	2.82	77.24	54.07	none	none	none	4.19	0.09	0.24	0.11	6.00	0.41	9.07	100.17	7.27	1.47	0.08	trace
9*	Lindal Moor (" No. 1)	3.35	86.20	60.34	trace	trace	0.04	1.43	0.08	0.43	trace	2.23	0.59	6.50	100.85	5.58	0 58	0.05	"
10	" (" No. 2)	2.35	66.60	46.62	"	"	none	5.96	0.13	0.23	0.07	6.61	1.94	16.28	100.20	14.02	1.76	0.10	"
11	Whitrigg's (puddling)........	1.97	83.33	58.33	none	none	trace	2.53	0.04	0.02	0.08	4.05	0.15	7.51	99.68	6.55	0.73	0.05	"
12	Brogden's (blast)............	1.80	67.14	47.00	"	"	none	4.45	trace	0.25	0.08	6.02	0.15	19.77	99.66	19.09	0.51	0.12	"
13*	Monsell Mine (best).........	2.28	83.94	58.76	0.03	0.01	"	none	0.09	0.09	0.28	0.65	none	13.17	100.66	12 37	6.48	0.10	0.09
14	" (average).....	1.40	69.41	48.59	none	none	0.03	"	0.06	0.06	0.08	0.44	0.13	27.97	99.48	25.92	1.53	0.07	0.04
15	Newton Mine (blast)........	3.08	77.61	54.35	trace	trace	trace	"	0.01	0.15	0.13	1.09	0.14	17.94	100.17	15.44	2.13	1.06	trace
16	Urswick (blast)..............	6.59	61.30	42.91	0.02	0.01	"	"	0.02	0.28	0.24	1.01	0.58	29.73	99.75	26.78	2.54	0.16	0.07

The names marked thus * are used for making iron by the Bessemer process.

pressure, is a constant, that is, $\frac{\delta}{w}=D$, a constant.

Let $\frac{\delta_1}{w_1}, \frac{\delta_2}{w_2}, \ldots \frac{\delta_n}{w_n}$ be a series of values of D, determined by experiment in a given bar: then,

$$D=\frac{1}{n}\left(\frac{\delta_1}{w^1}+\frac{\delta_2}{w_2}\ldots+\frac{\delta}{w}\right) \quad . . (3),$$

which gires the main value of this constant for a given bar.

Now, for the same material and length,

$$\frac{\delta}{w}, \text{ or } D\ a, \frac{1}{K d^2} \quad . . . . (4).$$

and when the section of the bar is square,

$$\frac{\delta}{w}, \text{ or } D\ a, \frac{1}{d^4} \quad . . . . (5).$$

If D_1 be put for the value of D, when $d=1$, then,

$$D_1=Dd^4.$$

$$=\frac{1}{n}\left(\frac{\delta_1}{w_1}+\frac{\delta_2}{w_2} \quad . . \quad +\frac{\delta_n}{w_n}\right)d^4 \ . (6),$$

which expresses the mean value of the deflection for unity of pressure and section. This mean value, therefore, may be taken as the *measure of the flexibility* of the bar, or as the *modulus of flexure*, since it measures the amount of deflection produced by a unit of pressure for a unity of section.

Substituting this value in *eq.* (2), we get

$$E=\frac{l^3}{4D_1} \quad . . . . (7),$$

which gives the mean value of the modulus of elasticity where D is determined from *eq.* (6).

The work, U, of deflection is expressed by the formula,

$$U=\tfrac{1}{2}\times w\times\frac{\delta}{12}=\frac{w\delta}{24} \quad . . . (8),$$

where δ is the deflection in in. corresponding to the pressure, w in lbs. If w and δ be taken at or near to the elastic limit, then this formula gives the work, or resistance analogous to impact, which the bar may undergo without suffering any injury in its material. This formula reduced to unity of section becomes

$$U=\frac{w\delta}{24K} \quad . . . . (9).$$

If C be a constant determined by experiment for the weight, W, straining the bar up to the limit of elasticity, so that the bar may be able to sustain the load without injury, then

$$\frac{W\,l}{4}=C\,K d \quad . . . . (10),$$

where $C=\frac{1}{6}S$, or $\frac{1}{6}$ of the corresponding resistance of the material per square inch at the upper and lower edges of the section.

$$*{*}*\ C=\frac{4\,Kd}{W\,l} \quad . . . . (11).$$

When the section of the bar is a square,

$$C=\frac{Wl}{4d^3} \quad . . . . (12),$$

which gives the value of C, *the modulus of*

TABLE No. II. SUMMARY OF RESULTS OF THE EXPERIMENTS ON TRANSVERSE STRAIN.

No. of Experiment.	Manufacturers.	Mark on Bar.	Date of Experiment.	Mean Value D of the Deflection of Pressure and Section by Eq. (6).	Mean Value of the Modulus of Elasticity E by Eq. (7).	Modulus of Elasticity E corresponding to 112 lbs. Pressure by Eq. (2).	Work of Deflection U up to the limit of Elasticity by Eq. (8).	Work of Deflection U for Unity of Section by Eq. (9).	Value of *e* the Unit of Working Strength by (Eq. (12).
									Tons.
1	The Barrow Hematite Steel Co.	H 1	June, 1866	.001308	30,096,000	33,830,000	77.944	77.917	6.860
2	do do	H 2	do	.001280	30,754,000	34,443,000	14.242	14.383	3.105
3	do do	H 3	do	.001319	29,717,000	32,717,000	20.155	19.757	3.540
4	The Barrow Hematite Steel Co.	H 1*	Jan., 1868	.001383	28,460,000	31,740,000	21.200	18.480	3.225
5	do do	H 2*	do	.001384	28,440,000	28,610,000	28.280	25.950	3.938
6	do do	H 3*	do	.001406	28,090,000	29,000,000	24.250	23.490	3.781
7	do do	H 4*	do	.001330	29,600,000	28,590,000	28.280	28.280	4.315
8	do do	H 5*	do	.001658	23,740,000	25,720,000	34.030	30.810	4.108
9	do do	H 6*	do	.001595	24,680,000	23,550,000	34.420	31.730	4.112
10	The Heaton Steel Company....	1	April, 1869	.001481	26,580,000	26,060,000	88.250	83.410	6.831
11	do do	2	do	.001354	29,070,000	29,640,000	108.400	101.100	7.819
12	do do	3	do	.001419	27,740,000	26,160,000	105.900	102.300	8.028
13	do do	4	do	.001295	30,400,000	35,120,000	102.300	100.300	8.094
14	do do	5	do	.001351	29,140,000	31,140,000	85.440	81.600	7.209
15	do do	6	do	.001372	28,690,000	27,590,000	80.210	77.130	6.925

strength or the *unit of working strength*, W, being the load determined by experiment, which strains the bar up to its elastic limit; this value of C gives the comparative permanent or working strength of the bar.

TABLE No. III. SUMMARY OF RESULTS OF THE EXPERIMENTS ON TENSILE STRAIN.

No. of Experiment.	Manufacturers.	Mark on Bar.	Date of Experiment.	Specific Gravity of Specimen.	Weight laid on in Pounds.	Breaking Strain per square inch of Section.		Corresponding Elongation per Unit of Length.	Value of U, or Work Produc'g rupture, by Eq. (13)	Remarks.
						Lbs.	Tons.			
1	The Barrow Hematite Steel Co.	H 1	June, 1867	7.7006	40,594	93,383	41.700	.0406	1895	Broke in neck.
2	do do	H 2	do	7.7710	30,304	89,724	36.030	.0866	3495	Broke in center.
3	do do	H 3	do	7.7899	30,304	68,607	30.630	.0656	2250	Broke 1½ in. from neck.
4	The Barrow Hematite Steel Co.	H 1*	Jan., 1868	7.7037	30,304	66,281	29.590	.1858	6157	Broke in center.
5	do do	H 2*	do	7.7978	33,574	72,341	32.690	.0312	1141	Broke 2 in. from center.
6	do do	H 3*	do	7.7952	32,014	68,758	30.690	.0812	2791	Broke 1½ in. from neck.
7	do do	H 4*	do	7.7956	35,334	75,736	33.810	.0906	3430	Broke in neck.
8	do do	H 5	do	7.8654	33,574	74,016	33.040	.0765	2831	Broke 1 in. from center.
9	do do	H 6*	do	7.8159	35,124	75,120	33.530	.1000	2756	Broke in center.
10	The Heaton Steel Company ..	1	April, 1869	7.8255	41,104	93,545	41.761	.0390	1824	Broke in neck.
11	do do	2	do	7.8176	42,199	93,526	41.752	.0312	1459	Broke in neck.
12	do do	3	do	7.8153	49,459	113,178	50.526	.0937	5302	Broke 2 in. from center.
13	do do	4	do	7.8003	45,828	134,869	46.816	.0364	1908	Broke in neck.
14	do do	5	do	7.8128	44,144	98,866	44.136	.0937	4631	Broke near neck.
15	do do	6	do	7.8166	46,924	105,093	46.915	.1041	5461	Broke 2 in. from neck.

TABLE No. IV. SUMMARY OF RESULTS OF THE EXPERIMENTS ON COMPRESSION.

No. of Experiment.	Manufacturers.	Mark on Bar.	Date of Experiment.	Greatest Weight laid on per square inch of Section.		Corresponding Compression per Unit of Length.	Value of U, or Work Expended in Crushing the Bar, by Eq. (13).	Remarks.
				Lbs.	Tons.			
1	The Barrow Hematite Steel Co.	H 1	June, 1857	225,568	100.700	.200	22,556	No cracks.
2	do do	H 2	do	225,568	100.700	.450	50,752	do
3	do do	H 3	do	225,568	100.700	.450	50,752	do
4	The Barrow Steel Company....	H 1*	Jan., 1868	225,568	100.700	.480	54,136	No cracks.
5	do do	H 2*	do	225,568	100·700	.525	59,211	do
6	do do	H 3*	do	225,568	100.700	.474	53,459	Slight cracks.
7	do do	H 4*	do	225,568	100.700	.392	44,211	No cracks.
8	do do	H 5*	do	225,568	100.700	.400	45,113	do
9	do do	H 6*	do	225,568	100.700	.400	45,113	do
10	The Heaton Steel Company ...	1	April, 1869	225,568	100.700	.333	37,557	No cracks.
11	do do	2	do	225,568	100.700	.288	32,481	do
12	do do	3	do	225,568	100.700	.257	28,985	do
13	do do	4	do	225,568	100.700	.247	27,857	do
14	do do	5	do	225,568	100.700	.257	28,985	do
15	do do	6	do	225,568	100.700	.288	32,481	do

Tensile Strain, &c.

The work, u, expended in the elongation of a uniform bar, 1 ft. in length, and 1 in. in section, is expressed by

$$U=\frac{1}{2} . K . \frac{L}{l}=\frac{1}{2} P_1 l_1 \quad . \quad . \quad (13),$$

where $P_1=\frac{P}{K}$ = the strain in lbs. reduced to unity of section, and $l_1=\frac{l}{L}$ = the corresponding elongation reduced to unity of length.

This value of u, determined for the different bars subjected to experiment, gives a comparative measure of their powers of resistance to a strain analogous to that of impact.

By taking P_1 to represent the crushing pressure per unity of length, and l_1 the corresponding compression per unity of length, the foregoing formula will express the work expended in crushing the bar.

We now proceed to the experiments tabulated in Table No. II, upon a collection of experimental bars, supplied from the Barrow Hematite Steel Company and Langley Mill, ranging from .995 in. to 1,044 in. square, the bearings being 4 ft. 6 in. apart.

The second series of experiments refer to the tensile strength of the steel from the Barrow Hematite Works and from Langley Mill, the length of the specimen being 8 in. and the diameter practically ¾ of an inch. Table No. III, shows the summarized results.

The third series of experiments referred to in Table No. IV, shows the power of resistances of the two classes of steel to compression. The average height of the specimens before experiments was .970, the diameter .72 in., the area being .4071 square inches.

Abstract of Experiments on Hematite Steel.

The strength of these bars, owing to their flexibility, is inferior to the strength of the other Bessemer steel bars before experimented upon. Taking the average of all these latter bars as the mean value of C, the unit of working strength is 5.8 tons; whereas the constant for the hematite bars is 4.2 tons, showing that the former are about one-third stronger than the latter. With about one-seventh more weight laid on the bars, their power of restitution was measured by about two-thirds of the whole deflection, showing that this load was considerably within that requisite to produce rupture. Owing to the high flexibility of the hematite bars, their modulus of elasticity is low. It may be here worthy of observation that for bars of the same length the modulus of elasticity varies inversely as the co-efficient (D_1) of the deflection for unity of pressure and section—that is $E \propto \frac{1}{D_1}$.

These bars underwent a great elongation by a tensile strain, and a large compression by a compressive strain, the average elongation being per unit of length .0792, and that of compression .419; whereas the three numbers for the other bars before experimented upon, did not on an average exceed .06 and .353 respectively, showing the flexibility and superiority of this steel in its powers to resist impact. The average tensile resistance of the bars is about 35 tons per square inch, whereas the resistance of the other Bessemer bars before experimented upon was about 42 tons, so that the tensile strength of the latter is one-fifth greater than that of the former.

The quality of hardness of steel and wrought iron, may be comparatively measured by the amount of extension under a given tensile strain, and the amount of compression under a given compressive strain.

Applying this test to the results of the experiments on the various steel bars, we find that the hardest steel bars were the strongest, *irrespective of the companies by whom they were manufactured.* We find, for example, that the elongation per unit of length for eight of the best Bessemer bars did not exceed .018, and the compression per unit of length did not exceed .25. These bars had a temper probably exceeding that of spring steel, and less than that for tools. The hematite bars are of a totally different description of steel from that manufactured for springs and tools, and this accounts for their comparatively low power of resistance.

Abstract of the Experiments on the Heaton Steel.

This steel being the product of a totally different process of manufacture from that of all the other steel bars previously experimented upon, it is a matter of great importance to know how it stands in relation to them as regards strength and those other properties which are peculiar to steel.

It is for this object that an abstract, separate from the Barrow steel manufacture, has been drawn up.

These bars, in their resistance to a transverse strain, show a very decided superiority over the steel bars before experimented upon. For instance, the mean value of C, the unit of working strength for these bars, is 7.49 tons; whereas the value of the other bars was only 5.746 tons, showing that these bars are 1.3 times stronger than the former bars. The value of U, or the work of deflection for unity of section for these bars, is 90.970, and for the other steel bars before experimented upon it is only 51.696. This value of U exhibits the power of the several bars to resist a force analogous to that of impact. It is therefore clearly shown that this steel must be peculiarly well adapted to resist a force of impact, considering that it is $1\frac{3}{4}$ times superior in the quality than in that of the previous bars.

The flexibility of the steel is somewhat inferior to that of the former bars, the measure of flexibility, D, being for those bars .001345, and for the other bars .001361. The modulus of elasticity is somewhat low for steel, although at the same time it is very little below that for the general average.

This steel, I consider, is well adapted to withstand a severe transverse strain, for it combines the two essential qualities of great strength and powers in its resistance to the force of impact.

The mean breaking tensile strain per square inch of action of this steel is 45.28 tons, whereas the value for the other steel bars before experimented upon is 41.77 tons. The Heaton steel is therefore 1.08 times stronger than the average result given for all the steel produced by other makers. The result, while placing the Heaton steel in a highly satisfactory position when compared with the mean of the whole steel experimented on, places it at the same time below that produced by some of the individual manufacturers.

The elongation of these bars was considerable, and a good deal above the mean for the other bars, thereby giving it a larger value for the work done in breaking the bars.

These bars show high powers of resistance to a compressive strain, all the specimens having undergone the test of 100 tons on the square inch, without any visible external signs of fracture.

From this abstract, it will be seen that this steel, manufactured by Mr. Heaton, stands in the most favorable light in comparison with steel produced by other manufacturers; and if it is taken into consideration that two-thirds of the iron from which the steel was converted was composed of Northamptonshire pig iron, we may reasonably look forward to this invention creating a considerable improvement in the production and the cost of steel.

After a short review of the comparative power of resistance of steel and iron, and the result of some experiments with a steel girder manufactured by the Barrow Hematite Steel Company, the author adds to his paper a detailed description of the furnace and apparatus for the manufacture of steel by the Heaton process, illustrated by diagrams of the same, and the paper concludes as follows:—"It is given by the patentee—and we have no doubt correctly—that the cost per ton of converting crude pig iron into 'crude steel,' exclusive of the cost of the pig, but allowing for the waste upon it at the ratio of 60 lbs. per ton, is £2 4s. per ton, or £1 15s. in crude steel cakes. The cost of making it into 'steel iron' bars *from the pig iron* is £3 10s. per ton of finished bars, and the cost of making into tilted cast steel bars from pig iron is £12 15s. per ton. We have seen the invoices of cast steel bars of this sort sold from Langley Mill at prices equal to those now current at Sheffield for well reputed cast steel made by cementation."

On Roads and Railways as affected by the Abrading and Transporting Power of Water.—The following abstract of a paper before the British Association, by Mr. Logan, on Indian Railways, is from the "Mechanics' Magazine":

The author commenced by stating general conclusions he had arrived at, to the effect that the abrading and transporting power of water was increased directly as the velocity and inversely as the depth; also, that when flowing water had once got its proper load of solid matter in suspension, all erosive action ceased. In short, that it was like a balance, the load being always equal to the power, which power, somehow or other, increased as the velocity became greater, and decreased as the depth of a stream increased, Nature always adjusting the load to the various circumstances. He then gave a short description of the plains and rivers of Northern India, and, by the aid of diagrams, went on to argue that rivers flowing through alluvial plains were raising rather than lowering their beds, and, though this silting-up process may be very slow, yet it was satisfactory to the engineer to know that the foundations of his bridges would be as safe, if not safer, a hundred years hence, as they are now. In speaking of the changes of the courses of rivers, he said that there was more or less a constant cutting going on on the concave banks of a river, with a silting-up process on the opposite side.

The next subject referred to was the denudation of the high level plains of Northern India, called "Doabs" (two waters), and locally known by the name of "Bhanger" land, in contra-distinction to the term "Khadir," or low valley lands, through which the large rivers, fed by the melting snows, now meander. Mr. Logan said that the higher ridges or "back bones" of these Doabs were not caused by any upheavals, but were formed by the denudation of these high level plains; and, as the rainfall was three or four times as great in the valley of the Ganges as that of the Indus, these back bones in the plains of the Punjab disappeared, as well as all defined drainage lines some fifty miles below the hills, for the simple reason that the water spread over these plains and was absorbed. To this peculiarity in the Punjab, particular attention was drawn; for Mr. Logan argued that, if standing crops and grass could permit without receiving injury the rain which fell higher up to flow through rather than over those standing crops, surely the same water could flow over an iron rail at very slow velocities, seldom, if ever rising to such a height as to interfere with a locomotive passing over the line; however, if it did, the obstruction could only last for not more than one day in a whole year. By acting on this principle, Mr. Logan believed that hundreds of thousands of pounds can be saved in the construction of railways in Upper India, as no embankments or masonry culverts and bridges would be required in crossing such high level plains as the Bechna Doabs, which he had surveyed; while pounding back these flood waters by embankments, and forcing it to find an escape through culverts, was most costly and dangerous, for it increased the abrading and transporting power of the water at the very point where alone it could do injury, namely, where it crossed the rails.

In support of his argument he quoted actual occurrences. He urged that deep foundations for bridges was the proper mode for spanning the large rivers of India, and that only one opening for both the main stream and the inundation water should be provided; while any little water that might be left behind in the swamps or low grounds which is below the level of the main river, should be drained off by spoon-mouthed syphons.—Speaking of the minor torrents, he briefly referred to another description of bridges, resting on inverts, with deep massive curtain walls, which may, with economy, be introduced in some instances; and concluded by stating that if once the abrading and transporting power of water was more fully investigated, the engineer could proceed with all descriptions of works affected by flowing water with greater confidence and economy, instancing harbors on the Madras coast, which province, from being at present a financial loss to the State, would soon become profitable, both to India and England, by increased commerce.

Sea-going Ships.—Mr. Merrifield read, before the British Association, extracts from the report of the committee on the state of knowledge of stability and sea-going qualities of ships. The report treated at considerable length on the rolling of ships in still water, followed by an account of the mechanism of waves, and an abridgement of what is known on the subject of the rolling of ships in wave water. The report itself being, in reality, a very condensed abstract of our existing knowledge, it would be difficult to make a useful selection for reading.—Meanwhile, it may be stated in general terms that the rolling of a ship in still water, and her behavior in a sea-way, although interdependent, involve very divergent conditions. It seems that the chief point to attend to, to secure easy rolling, is that the natural period of the ship's occillation should not coincide, or nearly coincide, with the period of the waves, and there seems reason to suppose that we already know how, in a rough way, to influence the natural periodic time of the ship, so as to be able to predict nearly in what wave she will and in what wave she will not roll through excessive angles and with excessive quickness. But our knowledge is exceedingly crude and deficient in detail, and even our known means of observation of the height and form of waves are very unsatisfactory. He also read several reasons by Mr. Froude for not agreeing with the committe.—*Mechanics' Magazine.*

FIRE-PROOF CONSTRUCTION.

From a paper read before the New York Chapter of the American Institute of Architects, April 5, 1869, by P. B. Wight, F. A. I. A.

A distinguished member of this body not long since remarked that a fire-proof building was easily defined: "It is a building which cannot burn, and which contains nothing that will burn."

It is very seldom that any building is required for such use that only non-combustible material shall be placed in it; but it is still a fact that fire-proof buildings are often called for, and are needed, wherein large amounts of combustible materials are to be placed.* To supply such a demand is one of the most important problems offered to the architect for solution. Of such buildings are storage warehouses, and stores or shops, wholesale and retail, as well as buildings for certain kinds of manufacturing processes, such as sugar houses and carriage or furniture shops.

Having devised a building of non-combustible material throughout, the question which next arises is, how to keep a conflagration in one part from extending to all the contents of the building? It seems to me, that in buildings for such purposes, the idea of making them only partially fire-proof is not to be considered for a moment, unless perhaps the material contained is so highly inflammable that it would destroy the material of the building, even if it is divided into fire-proof compartments, in which case it seems to be folly to go to the expense of fire-proof materials at all. When you know that no part of your building can burn of itself, it is evident that every atom of it will offer some resistance to the enemy confined within. I believe, too, that it is impossible to smother or choke a fire once commenced, by the use of closed compartments. Accident or carelessness may leave some openings which will facilitate a draught in some unforeseen way. And even supposing that you have shut in your fire by some arrangement of closed compartments, can you give your compartments less air than a charcoal pit? Close it as much as you will, your confined goods, if the barriers are not forced by the immense power generated by the heat, will at last be reduced to charcoal; for you cannot open a door or window upon such a smoldering fire, but that it will instantly burst into flames. Ships have been brought into port with smoldering fires under their closed hatches, which have been in existence for weeks at a time, while but few have been eventually saved under such circumstances, except by scuttling. Such conditions do not exist with regard to buildings; in them there is not the risk of human lives, which may be saved on shipboard only by closing down the hatches, and scuttling is obviously out of the question.

Store-houses are the only class of buildings which admit of division into air-tight compartments, and there is a practical objection to them in even buildings of this class; but few kinds of goods can be preserved without good ventilation. It seems, therefore, that the compartments should be open and accessible from without, but carefully divided from each other. If so, they afford good facilities to those employed in extinguishing fires; and I think that in a building thus arranged there would be a more reasonable chance of a portion of its goods being saved.

The division of buildings into horizontal compartments, rather than vertical ones, is so much more desirable, where land is expensive, that inventors have almost exhausted their ingenuity in devising thoroughly fire-proof floors. It is obvious, however, that the division of a building by vertical fire-proof partitions, is a matter so easy of accomplishment, that it is questionable whether the horizontal division, so beset with practical difficulties, so expensive, and withal so much less to be depended upon, even when the best systems of construction are used, is ever economical, even where ground is expensive. I even question whether it is of any use to build iron floors, or floors with iron supports, for buildings to contain goods; brick piers and groined arches are alone reliable. If you divide horizontally, you must have stairways within and windows on the exterior, both of which welcome the ascending flames. You may enclose your staircase in a fire-proof enclosure, and you may put the heaviest iron shutters on your windows, but you must have doors through which to gain access from your stairways, and you must open your shutters when you want light. There is a contingency that those traps may be set when the enemy comes, and then all your expensive floors represent so much wasted capital.

* But, by combustible material, I do not by any means intend what the insurance companies call hazardous, but dry goods, books and similar things, which will burn independently of the building in which they are contained.

As yet, I believe that no buildings in this vicinity, built purely for storage purposes, have been constructed entirely of fire-proof materials, except the St. John's Depot of the Hudson River Railroad Company. I am not aware that any attempt has been made in these buildings to stop a conflagration among the goods on storage, either by horizontal or vertical compartments. The floors, to be sure, are of iron and brick, non-combustible, but with hoistways; and it is not difficult to conjecture, even supposing that all horizontal openings and iron shutters were closed, what would be the result of a fire raging on one of those floors, hundreds of feet in expanse.

Several fires occurring recently in the Brooklyn warehouses, have warned their owners to take extra precautions, even though none of these warehouses are fire-proof, if I am rightly informed. One of the best is known as the Pierrepont Stores, near the Wall street ferry, and the arrangement of them is well worthy of notice. These are about three hundred feet in length, and are divided into six compartments by fire-proof party walls; the width of each compartment is consequently about fifty feet, and the length about two hundred feet. The floors are of wood, and it would have been useless to make them of iron and brick; for the goods taken in them are mainly sugars, and it would be folly to attempt to arrest a fire of such combustible material in its ascending course, by any practicable devise. But what is most interesting in these buildings is, that each is fortified against its neighbor. Recently the party walls were carried up about six feet above the roofs, and were pierced with embrasures, through which firemen can play from the roof of one buiding upon the flames in another, with perfect safety to themselves. Here is an instance wherein capital would have been wasted on the expensive materials required for fire-proof floors.

It is the duty of the architect, as I conceive it, to guide the capitalist in coming to a decision on such points. If he devises economical methods, his commission is lessened, but thereby so much more capital remains unemployed, but ready for investment in other enterprises. It would be foreign to my subject to enlarge upon this point, and show how much more it is to the interest of the architect to study reasonable economy in his work, especially buildings for business purposes; but I will let the suggestion stand for what it is worth. Perhaps a knowledge of the fact that most members of our profession agree with me in this opinion, would go far towards disarming the misgivings of many a client upon the question of commissions.

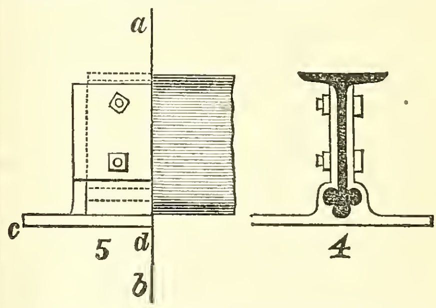
Buildings for manufacturing purposes next demand attention. Some time since a manufacturer and contractor for iron work remarked to me, that if some one would only put up a large fire-proof building, with good steam power, to be rented out for manufacturing purposes, his fortune would easily be made. I have often thought of the suggestion, and wonder why it had not been acted upon. He said that at that time it would be impossible to hire a fire-proof shop or room, with power, in this city. Now, there are many occupations requiring delicate, and not easily replaced machinery, or in which are involved elaborate experiments, running for long periods—the derangement of which could not be recompensed by any amount of insurance—for which a fire-proof building would be almost invaluable. The saving of insurance on such a building and its contents would be greater than the interest on the extra cost of fire-proof floors, and would enable the owner to rent his rooms at a lower rate—in proportion to the equivalent given—than could the owners of buildings with wooden floors. The extra cost of fire-proof construction in a manufacturing building is small when compared with that of a bank or public building. The walls and ceilings require neither lath nor furring, and the floors may be of flags or slate, bedded on the brick arches, or what is better, plates of cast iron bolted to the beams—which will presently be described. All inside finish may be discarded, and iron doors, of No. 16 iron, with light wrought-iron frames, hung to stone templates in the jambs, are the only safe coverings required for the openings.

Such fire-proof buildings, as have been erected for manufacturing purposes, have been specially designed for single occupants. The most perfect and the earliest that I know of, is a building erected on Vestry street, about ten years since, for the Grocers' Sugar Refining Company. This building, as far as its material is concerned, is absolutely fire-proof. It is most remarkable for its floors, which are made of plates of boiler-iron riveted together and secured to the beams in large sheets. This is the most simple system of floor construction I have ever seen, and has many advantages. But I have not seen the building in use, and do not know the floors answer the ends for which they are intended.

Some of the new buildings for the various gas works in this city are fire-proof. The best are those of the Metropolitan Company, at the foot of Forty-second street, North river. But they are, at best, only sheds—brick walls, with iron shutters and roofs. Large, open, and well ventilated, they serve their purposes well; but they can hardly be called architecture.

The most extensive attempt to build a fire-proof building for manufacturing purposes was the enterprise of Harper and Brothers. This was one of the pioneer buildings of the new dispensation. The Harper girder is well known: it is an ornamental cast-iron beam, with a tie rod, and was the father of the truss beam, now so extensively used for supporting the rear walls of stores. It has been succeeded by the built-up beam, now generally used for girders, and the double rolled beam. It was eminently a constructive beam, using iron according to its best properties, cast-iron for compression and wrought-iron for tension. I doubt not that it will some day be again used where girders are required. The built-up beam was invented for the restorers of the "pure" styles, who think that furring strips, laths, plaster, and a modicum of run moldings, not to forget "a neat panel on the soffit," to be a good substitute for the honest lintel of the Greeks, and more artistic than the constructive beam which Mr. Bogardus designed for the Harpers. When men are no longer ashamed to display good iron construction, and bend their artistic conceptions to their constructive skill, we may hope to see something like the Harper beam revived, and decorated in a manner befitting its use.—But I fear that this will be done when a more rational generation than our own holds sway. But to return. In Harpers' building, as in the Cooper building, the deck beam was used for the floors, and brick arches, such as those now in use, were employed. The deck beam has also gone out of use. When first employed, iron beams were not made for houses, but for ships.—The I beam has replaced the deck beam for the former purpose. And in this connection, I would suggest an inquiry into the practicability of using the deck beam inverted.—It has always seemed to me that the broad flange would best sustain compression, and that the roll, having the form of a round bar, would best resist tension. The matter of the bearings is easily remedied by a cast-iron shoe on each end of the beam and bolted to it. This shoe, with a broad foot, would answer the purpose both of template and anchor, and if made to project from the wall and assume an ornamental shape, might become a visible and constructive bracket. The deck beam inverted would evidently present the best appearance from below in cases where the flooring is placed on top of the beams—the various methods of doing which I propose to discuss further on.—Should the deck beam come again into use, it might be made of more ornamental form without detriment to its strength. The bottom roll or flange could be molded in various ways, as is here suggested:

These forms could easily be developed between the rollers. The shoes for the ends of beams might be of this form:*



But, except in so far as the floors are concerned, the Messrs. Harpers' building is far from being fire-proof. There is much woodwork in its inside finish, and the contents being of a highly inflammable nature, I fear that fire would have its own way in that building unless early checked.†

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* Figs. 4 and 5 represent a section and side elevation of the beam shown in fig. 3 with a cast-iron shoe; *a b* is the face of wall, and *c d* is the bearing of the shoe on the wall.

† An inspection of Harper and Brothers' building, since writing this paper, has convinced me that the principle of division into horizontal compartments has been carried out more thoroughly in it than in any other building of the kind. There are no openings through the floors. It contains neither interior stairs

Of banks and insurance buildings we certainly have a large number which are, to all intents, fire-proof, though but few are thoroughly so. It is generally admitted that such buildings are not in danger from their contents, and to this belief may be ascribed the fact that we already have so many of this class. The Continental Bank, the American Exchange Bank, the Mutual Life Insurance Company's building, the Park Bank and the City Bank building, recently remodelled, are absolutely fire-proof. Nothing less than a bonfire of all the furniture, books and papers that could be collected together in any one room of any of these buildings would endanger its destruction. They are safe from any ordinary casualty. But in all the rest there is enough woodwork to make the word "fire proof," as applied to them, of very doubtful significance. To show what a practical eye the insurance companies have, let me say that in nearly all the so-called fire-proof bank buildings the rates of insurance are as high as in ordinary business buildings. The rates are unusually high in the building which I happen to occupy, on account of a well hole in the center which is trimmed with wood, and would carry a fire through the whole building in an instant. What I might say in relation to buildings of this class will be comprised in some practical suggestions upon fire-proof buildings generally. Let us then look for a few moments into the matter of constructive details.

And, firstly, how shall floors be constructed? Before the "iron period," when our Washington Capitol, our City Hall, our Old Exchange and Custom House were built, the Roman and Mediæval vaults only were used—either of stone or of brick, plastered. When the width of a room was too great for one span, granite columns or brick piers were used, as in our old Exchange, now the Custom House. The floors above the vaults were leveled up and paved with flags or marble tiles. As far as grace, strength, and absolute relief from the dangers of fire were concerned, this was a perfect system. But now space is demanded; there must be no more heavy piers and no great thickness of floors. We are therefore forced to use a material which, though not combustible of itself, will do little work if exposed to great heat; and in this is seen the great difference between our fire-proof buildings of the brick period and those of the iron period, and the inferior fire-proof qualities of the latter. The problem now is to use the minimum of brick and the maximum of iron. I think, therefore, it must be conceded that with the best we can do with this material there is danger; and the problem might be put thus: "Given iron, make as nearly fire-proof buildings as possible out of it." What then has been done with it thus far? For columns, we have used cast tubes of all shapes and sizes, and the wrought iron pillars of the Phœnix Iron Company. For girders, we have used compound beams of cast iron, with wrought ties; built-up beams of various forms of rolled and plate iron, bolted and riveted together; and common rolled beams, used double. For floor beams we first used deck beams for wide spans, and railroad iron for narrow spans; these have now been superseded by the I-beam of various sizes. The rolling mills now have on their circulars I-beams of great dimensions and suitable for girders, but refuse to fill any but large orders; indeed, I believe that only one mill has rollers for beams larger than thirteen inches, while the others will not put up machinery until they get large enough offers. So we are thus far deprived of large smooth beams of one piece for girders of long span—beams which no one would desire to hide from view, but which might honestly tell their use to every beholder. For supports between beams we have had Peter Cooper's terra cotta pots and the four inch brick arches. The former are out of use, and the latter are almost universally employed. Corrugated iron—first used in the Columbian Insurance building by Mr. Diaper—has also gone out of use. The destruction of the Fulton Bank, a so-called fire-proof building, sealed its fate as far as floors are concerned.* We have also had the experiment of stone floors in the American Exchange Bank, by Mr. Eidlitz, and repeated by another architect in the Mutual Benefit Life Insurance Building at Newark, N. J. The stone slabs, brick arches, and the Parisian floors—of plaster or concrete bedded upon bar iron gratings inserted between the beams—are the only practical systems of fire-proof floor construction now in use. The only attempt

nor hoistways; both are on the exterior. The stairs are in an isolated tower approached by bridges, and the hoistway is without enclosure. This arrangement is, however, extremely inconvenient.

* That disaster was owing also to the fact that the beams, other than girders, were made only of No. 12 sheet iron with flanges of two-inch angle iron.

to lay the floor *on* the beams of which I have knowledge is in the sugar house before mentioned. This has suggested to me several methods of laying rigid floors upon beams at considerable spaces (three to five feet) from one another. Preliminary to so doing I have suggested the revival of the deck beam, or the I-beam with a better form for the bottom flange, and the adoption of cast iron shoes for the bearings.

The objections to the brick arches are that their great weight requires heavier beams than would otherwise be used, and that the form of their soffits is not beautiful: for they have the appearance of a long succession of little wagon vaults, requiring a resort to the doubtful expedient of furring the ceiling with iron lath. I think it might be objected to the French system of floors that the expense would be too great, plaster being a dear article with us in comparison with its price in France, while our own cement has not the requisite properties to enable it to be substituted, besides being almost equally costly. The stone slabs of Mr. Eidlitz are the only rigid material thus far used successfully with iron beams, and could be used to better advantage if laid *on* the beams rather than resting upon their lower flanges, as is done in the American Exchange Bank. They are doubtless the handsomest material that can be used for this purpose, but are open to the objection of being heavy and expensive—where expense is a question, and utility only is sought—requiring heavy beams and calling for elaborate cutting on the under side. It will be pertinent to our inquiry, therefore, to ask if there are any other rigid materials adaptable to this purpose, and possessing the desired quality of lightness and cheapness. A former draughtsman of mine, now a member of the Institute, first suggested the use of slabs of slate, about two inches in thickness, for spans of four feet, and thicker or thinner in proportion to the distance of the beams from centers. I give his suggestion for what it is worth. But it led me to believe that we would eventually come to cast iron as the practicable material for this purpose, possessing the requisite qualities of lightness and cheapness, and capable of being bolted to the beams, thus answering all the purposes of flooring and bridging. Cast iron plates may be used for flooring in two ways: first, when deafening and finished floor covering are required; second, when neither is required, as in manufacturing buildings, wherein a reasonably smooth flooring is required, and a few planks, laid where workmen habitually stand, will answer the purpose of non-conducters of heat. Experiment must determine the minimum quantity of iron (in proportion to the strength required) to be used in the floor plates. In obtaining the proper form of strength, and to ensure true castings, the bottoms of the plates will naturally be covered with raised flanges, except at the edges where they bear on the beams. These flanges or beams may assume a decorative form, either a plain diaper or a larger pattern, to form a complete design for the ceiling when many of them are combined. By a judicious arrangement of the flanges the actual thickness of the iron may be reduced to three-eights, or a quarter of an inch. When deafening is required, strengthening flanges may also be cast on top of the plates, and consequently the beams can be placed at wide intervals. The flanges on the top will then serve to keep the concrete used for deafening in its place, and avoid the cracks which might occur in a large surface of cement. The deafening may be of any thickness required, and will serve as a bed for the floor tiles. All that is then required for the underside is judicious decoration of the beams and floor-plates. When deafening is not required, as in manufacturing buildings, the tops should be smooth. It has been objected by a manufacturer, to whom I explained this system of construction, that the floors of iron would be too cold for the feet of workmen. But it would be very easy to put down platforms of wood where the men habitually stand. Besides, when the lower story is heated, the stratum of hot air immediately under the ceiling would naturally keep the floor at a higher temperature than that of the air in the room, and the greater conductibility of the iron would rather tend to warm the feet of those who stand upon it. The plates, in all cases being bolted to the flanges of the beams, would serve as bridging for the floors.

By the above described construction of floors, I would attempt to get rid of the obnoxious and expensive iron lath, so generally used. But it is more difficult to avoid their use on side walls, when the walls are to be plastered—and let me say here that there can be no excuse for plastering the side walls in a fire-proof building, except for economy's sake. The easiest and by all means the cheapest expedient when plastering is required is to build four-inch walls, secured to the main exterior walls by iron straps. These will not conflict with the building laws, provided you build your walls thick enough at the outset. There is, however, no better way in which to finish interior walls than to line them with stone or marble, or both combined. Where decorative effect is desired I would use stone with marble panels. Our native quarries now afford stone light enough in color to set at rest all objections that may be made to its use on the score of light. But if those should hold good the material might be marble paneled with marble, the former white and the latter colored. Obviously, the cheapest material for wall covering in natural materials would be slabs of white marble. Let us, then, make some comparison of figures, and see what can be done with this material. Iron lath, of the form generally used, cost 1.25 dols. per foot. Three-coat plastering costs nine cents per foot. A responsible dealer in marble informs me that he will put up inch slabs of Italian veined or Vermont marble for one dollar and a half per foot. Which, then, would you choose, polished marble at 1.50 dols., or plaster, as good in appearance as that in any tenement house, at 1.34 dols.? This is a fair comparison for exterior walls or ceilings. Italian marble slabs can be procured in any quantity, from eight to nine feet long and three feet wide. In a room fifteen feet high, allowing four feet for wainscot and two feet for cornice, you may line your wall with one length of marble.

What treatment do we now give to doors? We build brick jambs with wooden or iron lintels, as if we would trim the doors with wood. We then put up cast iron jambs, rivet to their edges pilasters or architraves of the same material, and then surmount the whole, perhaps, with a cast iron cornice and pediment. Some have gone so far as to inlay the panels of the iron work with bits of colored marble, thus heightening the effect of the already rough finish of the iron, a roughness which the best foundrymen have been unable to prevent, and which it would cost untold money to reduce down to the smoothness of ordinary work in pine wood. In one of the most pretentious houses on Fifth Avenue they are now putting up jambs, architraves, and cornices made of sawn slabs of marble or marble boards in the same manner in which wood and iron have been used. And what does all this amount to? In the category of shams there is no equal to this monstrous succession. You have imitated a Greek or Roman architrave and cornice by a wooden sham, your wooden sham has been imitated by an iron sham, your iron sham has been imitated by a marble sham; and what is the result? You have kept the form all along; you have come back to the original material by a succession of imitations, and have at last a shell without meat, marble carpentry instead of marble architecture. In all the stages of your attempt to revive the old forms you have sham imitations of shams down to the final achievement of your carpenter in marble. Next must follow, I suppose, the imitation-marble vendor, who will crown the whole fabric of shams and give you something which can as much be called architecture as Mr. Shoddy's painted "red backs" and "blue backs" resemble standard literature. I offer no original suggestion to remedy this condition of affairs. Go back to your old Greek, go back to your old Roman models, if you like them, and, seeing how they are built, go and do likewise; but spare us these sham contrivances. Set up your door posts and plant your lintel upon them, whether for exterior or interior use, and carve them to suit your fancy. They will be at least good so long as they be genuine and strong. Then figure up the cost of this kind of work, and see how much you have saved for your clients.

In conclusion, let me urge you to study diligently the various problems affecting this subject which, in your experience, are continually offered for solution. In so doing, look mainly to a practical solution of the questions which may arise, and free yourselves from all consideration of so-called rules of art, which might control you. The development of architectural design was no less affected by local and circumstantial conditions with the ancients than it is with us; but the conditions at the present time are essentially different from and decidedly more various than those which controlled our ancestors, whether of the classic or mediæval period. Whatever may have been achieved by art in those times was the result of, and co-ordinate with the practical solution of problems then offered.

We have ignored the conditions which especially affect us, and the result is that our architecture, for whatever purpose, is without originality, and wholly irrational.

As long as we allow ourselves to be governed by rules of art founded on the experience of the past, and precedents established by conditions which now do not exist, we need hope neither for good construction nor good art. The attempt to engraft the traditions of the past upon the practical work of this century has resulted in failures involving the waste of hundreds of millions of capital in this country alone; I might name from memory a score of buildings, many of them the most prominent, and all the most costly that have been erected, in proof of this assertion. I would commence with our national Capitol, in whose dome may be seen the most flagrant attempt in all modern times to perpetuate a traditionary style in a material entirely different from that in which the style was developed—so different that the foundations under it could not carry the superstructure if it were erected of the material for which it would appear to have been designed; and for want of foundations of sufficient breadth, even to carry the iron work, it has been necessary to carry the whole exterior iron colonnade upon iron brackets, concealed beneath what appears to be the podium for the whole dome, but which is, in reality, a box of thin plates of cast iron, secured to a light framework built out over the roof of the building.

In erecting modern fire-proof buildings, especially in so far as iron work is concerned, all the conditions imposed upon the architect are different from those which existed in past ages. The same may be said of the use of iron in any building. Subserviency to style, when the material used is not such as was the controlling element of that style, is destructive to all good art; for there can be no truly artistic effect except that which is produced by the best use of material, and its decoration in best accordance with its nature. If the use of iron is ever to lead to the erection of buildings worthy of being called works of art, such a result must be attained only by the recognition of this principle.

The best thinkers have doubted whether there can be any such thing as architecture in iron, assuming, of course, that to be called architecture the material must be constructively used; and there is good reason for these doubts. An iron building does not always require the force of gravity to maintain the cohesion of its parts; it possesses such properties that it may be swung in the air or balanced on a single point, if it is necessary so to do. It is a machine admitting of as little decoration as a steam engine or a printing press. If iron alone were used for buildings, constructive necessity and economy combined might lead us to build houses like steam boilers or water tanks.

What has been done thus far toward the erection of iron buildings on constructive principles? We can only recur to the buildings of the Crystal Palace pattern. We had a beautiful one in New York, admirably constructed, and well designed for its purpose; but even that building was decorated in the Moresque style, perhaps as nearly appropriate to the material employed as any that could have been selected. Here originality in treatment failed just where it was wanted. The same constructive principles were involved in the design of this building which would have been involved in the erection of a fire-proof building. In this respect it was a success.

In the erection of fire-proof buildings, we are forced to do the best we can with iron while using it in the most varied capacities; but when its use can be spared, let me entreat you to rid yourselves of it; where it must be employed, use it rationally and constructively; but better not decorate it at all than imitate styles not in harmony with its constructive properties. As all iron must be painted, I am inclined to believe that the best method of decorating it is in colors; for this treatment the iron must be plain and simple, and the colors may be proportionately brilliant. With regard to other materials, I would suggest nothing more than is said above—in all things build rationally. First, let your work be strong and well balanced—no part too heavy—no part too light. Then decorate it in harmony with its constructive features, never concealing materials except where necessary to protect them, and emphasizing the main lines of the construction by ornamentation. Thus only can the great problem of the day be solved, and the fire-proof architecture of the nineteenth century be made worthy of a rational and progressive age.

Since this paper has been printed I have discovered several unintentional errors of statement, which I am glad to have an opportunity to correct. The Harper's building was not the work of Mr. Bogardus, but was designed and built by James L. Jackson and Brother, of this city. In saying that "but one mill has rollers for beams larger than thirteen inches," I should have added that fifteen-inch rolled beams had been made for some time by the Buffalo Union Iron Works. In giving Mr. Diaper credit for having first introduced fire-proof floors of corrugated iron and cement I did not go back far enough in point of time. The first building in which he used this system of floor construction was the old Bank for Savings, in Chambers street, which was torn down some years since.

I should have mentioned, among fire-proof manufacturing buildings for special purposes, the well built—though far from beautiful—building of the Singer Manufacturing Company, in Mott street. I have recently examined it with much interest. This building has stood one of the most severe tests to which a building can be exposed. About a year ago a fire broke out in the lacquering room, which contained a large amount of combustible materials, but, though the fire raged for several hours, the building was not materially injured. The beams in this building are of wrought and cast iron combined—they are a patented invention of the Architectural Iron Works Company—and of section similar to a letter Y inverted. They are placed three feet from centers, and carry four-inch brick arches. I have not seen these beams used elsewhere. I might also have mentioned among fire-proof warehouses the building of the U. S. Warehousing Co., in South Brooklyn, known among grain merchants as "The Iron Elevator."

STEAM CRANE BOILERS.—The increasing number of boilers used for steam crane and other similar portable purposes renders it important that any dangerous defects to which these boilers are liable should be generally known. The explosion of these boilers has become by no means unfrequent; and, as they are now constantly used in the erection of public buildings, and sometimes in close proximity to crowded thoroughfares, the subject becomes of increasing importance. We therefore take the present opportunity of placing before our readers a few points in connection with this class of boilers which are referred to by Mr. Fletcher in a recent report to the Manchester Steam Users' Association. The boiler to which reference was specially made was of the internally-fired vertical class, cylindrical in the external casing, as well as in the internal firebox, and domed on the top, while the flames from the firebox passed off to the chimney through a single central uptake tube, which formed a most important tie between the crown of the firebox and that of the external casing. Boilers of this type are very simple in construction, and well calculated, when new, to resist a high pressure, so that they are very generally adopted. The dimensions of the one under consideration were—height, 8 ft. 9 in.; diameter, 3 ft. 6 in. in the external shell, and 2 ft. 9 in. in the firebox, while the thickness of the plates was 5-16 in., and the load on the safety valve per square inch, 70 lbs. In this boiler there was found a deep groove or furrow running entirely round the inner casing of the firebox at the bottom of the water space, and eating into the metal to a depth varying from 1-8 in. to 3-16 in., so that more than half the strength of the plate was gone. This is not a peculiar case; others very similar have been met with, and especial danger arises from the fact that these grooves are very difficult to detect. They take place so low in the water space as to be very nearly, if not entirely, concealed by the blocking ring at the bottom, while the only opportunity of examining them is through one or two small sight holes cut through the outer casing.

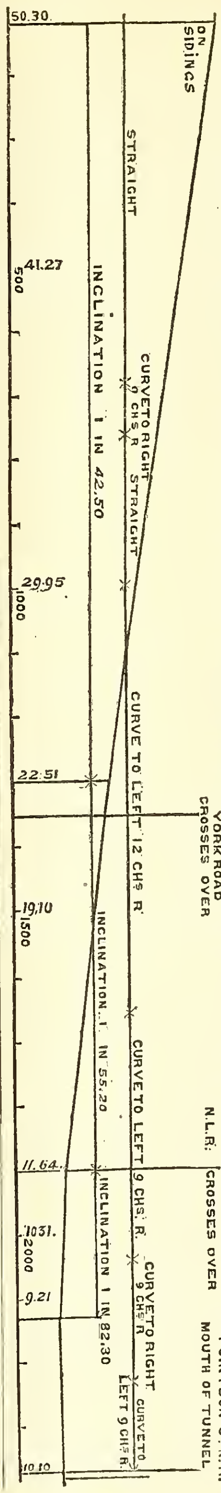
It is frequently supposed that because boilers are small therefore they are safe, whereas the fact of their being small makes them dangerous. Small boilers cannot be inspected as larger ones can, since they do not admit of access for a man, and therefore they are to a greater or less extent apt to be worked on at a risk. The internal examination of portable boilers, so important to their safety, is a question which hitherto has not received that consideration which it deserves, but the subject should no longer be neglected. It is well worthy of the attention of engineers to endeavor to construct such portable boilers as are too small to admit of a man's getting inside so that they may be taken to pieces for examination, and it becomes imperative either that arrangements should be made for doing this, or that these boilers should not be allowed to work on for more than three or five years without being cut open for examination, whatever the inconvenience might be. No doubt if the attention of engineers were directed to this subject, inventive talent would soon construct boilers that could without much difficulty be taken to pieces so as to be examined internally, and thus their safety ensured.—*Mechanics' Magazine.*

WORKING GRADIENTS WITH A RUN.

From "Engineering."

There are few more interesting examples of the utilization of the "work" stored up in a moving mass than that afforded by a railway train mounting by the aid of a "run" an incline up which the attached engine would otherwise be unable to draw it. The spectacle is such a common one to most railway men that probably but few ever devote a second thought to the principle involved in this method of working a gradient, and yet these principles are very simple, and a proper appreciation of them is frequently of considerable use in practice. Under these circumstances we propose devoting a little space to a consideration of this method of working gradients, in the hope that our remarks may be regarded with interest by those who have not hitherto paid the subject the attention it deserves.

A railway train, moving at any given velocity, has stored in it an amount of energy or "work," which, expressed in the ordinary units or foot-pounds, is equal to the weight of the train in pounds multiplied by the height in feet through which a body would have to fall in order to acquire the velocity with which the train is moving. In other words, a train moving at any given speed would, if it were possible to direct its motion directly upwards without checking it, rise into the air to the height from which a body would have to fall to attain the same speed as the train. In practice, it would, of course, be impossible to alter the direction of motion of a train suddenly from a horizontal to a vertical one; but if we suppose, for the present, that the train is exposed to no retardation from friction, the law will equally apply if, instead of the train being made to move directly upwards, it is made to traverse a gradually ascending incline. Let us, for instance, suppose a train to be moving at the rate of 44 ft. per second—a velocity which would be acquired by a body in falling 30.062 ft.,* or say, 30



ft., then that train, if directed on to a rising gradient would, if there were no retardation from friction, ascend that gradient until it reached a point 30 ft. above its original level. If the gradient rose at the rate of 1 in 100, the train would thus mount it for a distance of $30 \times 100 = 3{,}000$ ft., or, if its inclination were 1 in 50, it would traverse it for a distance of $30 \times 50 = 1{,}500$ ft., and so on; the steeper the gradient the less of course being the distance to which the train would have to pass up it to attain the required elevation above the starting point. If the gradient did not rise to the height to which the energy stored in the moving train would be sufficient to carry the latter, then the train on reaching the top of the incline would have a certain residual velocity, this velocity being equal to that which would be acquired by a body in pulling through a space equal to the difference between the rise of the incline and the height to which the train would have mounted. Thus, if we suppose the train moving at a velocity of 44 ft. per second, which we have already taken as an example, to be turned on to an incline rising only 20 ft., it would on reaching the top have a residual velocity equal to that which would be acquired by a body in falling

* The height from which the body must fall *in vacuo*, in order to acquire the given velocity, is, of course, calculated by the ordinary formula, $h = \frac{v^2}{64.4}$; h being the height in feet, and v the velocity in feet per second. For all ordinary practical purposes, the divisor in the above equation may be taken as 64, the formula then being $h = \frac{v^2}{64}$. Similarly, the velocity due to the height fallen is given by the formula $v = 8\sqrt{h}$.

through a space of 30.062—20 = 10.062 ft., or a little over 25 ft. per second.

It follows from what we have already stated that, so long as we suppose the motion of the train to be unretarded by friction, the vertical height to which it will ascend when launched upon a rising gradient at any given speed will be quite independent of the inclination of that gradient. As soon, however, as we take friction into consideration, this law becomes modified, for the flatter the incline the greater will be the distance to which it will have to be traversed by the train in order to attain a certain elevation, and the greater, therefore, will be the space through which the retarding power of friction will be exercised. Arguing upon this fact, it may be considered that, if an incline is to be worked by "taking a run" at it, it will be best to make it as steep as possible, and thus reduce the length necessary for rising a given height; and to a certain extent—but to a certain extent only—this is correct. If a train was allowed to pass suddenly from a level line to a steep gradient, however, a great portion of its energy would be expended in effecting the damage to the rails and rolling stock due to the sudden impact of the wheels with the ascending rails of the gradient, and the more steep that gradient was, the greater the loss due to this cause would be. Even if the very steep incline was united to the level line by a gradient curved in a vertical plane so as gradually to alter the direction of motion of the train, the centrifugal force generated by the passage of the train over this portion of the line at a high speed would materially increase the pressure upon the rails, and thus augment friction. Moreover, it is but seldom that a train is intended to surmount gradients by a "run" alone, it being usually assisted in ascending by the power exerted by an attached engine, and it must be remembered that the shorter the incline the less is the number of revolutions which the wheels of the engine will make in ascending it, and the less, therefore, will be the amount of work which the engine will be capable of developing during the ascent. It will thus be seen that there are, in most cases, practical objections to the employment of inclines much steeper than those in general use.

It may, perhaps, assist in rendering clearer the principles we have been explaining, if we apply them to an actual example; and for this purpose we shall consider the working of the incline connecting the North London and Great Northern lines near King's-cross, the details of which have been kindly furnished to us by Mr. William Adams, of the North London Railway. The incline we have mentioned is altogether 2,016 ft. in length (measured along the gradient), and in this length it rises 41.3 ft., the mean gradient being thus 1 in 48.81. The actual gradient varies, however, as shown in the annexed section, from 1 in 82.3 to 1 in 42.5, and the lower part of the incline is, moreover, curved as marked on the sketch. As far as the question of working the incline with a run is concerned, however, the variation in the rate of inclination is of no consequence, the only matter to be taken into consideration being the length and the total rise. The gradient is worked by engines having 17 in. cylinders, 24 in. stroke, and four coupled wheels 5 ft. 9 in. in diameter, the weight in working order being 42 tons, of which 30 tons rests upon the coupled wheels. These engines take up regularly trains consisting of twenty loaded coal trucks and two brake vans; the trucks weighing 5 tons each and carrying 9 tons of coal, and the brake vans weighing each $8\frac{1}{2}$ tons. The total load, including engine, is thus 339 tons.

In ascending the incline the work to be done consists, first, in actually lifting the 339 tons through a height of 41.3 ft., and, secondly, in overcoming the frictional resistances of the engine and train while traversing the length of the gradient, namely, 2,016 ft. The first mentioned portion of the work, of course, amounts to $339 \times 2240 \times 41.3 = 31,361,568$ foot-pounds, and the second portion may be fairly estimated as follows:

	Lbs.
Frictional resistance of engine at 18 lbs. per ton $= 42 \times 18 =$	756
Frictional resistance of train at 8 lbs. per ton $= 297 \times 8 =$	2,376
Total frictional resistance	3,132

This resistance has to be overcome through a distance of 2,016 ft., corresponding to the exertion of $2,016 \times 3,132 = 6,304,112$ foot-pounds, which, added to the amount due to the actual lifting of the train, makes a total of $31,361,568 + 6,304,112 = 37,665,680$ as the number of foot-pounds of work to be expended in conveying the train up the gradient.

We now come to the question of how this power is to be provided. The engines used exert—as may be calculated by the ordinary rule—a tractive power of 100.5 lbs. for each pound of effective pressure per square inch on the pistons; and as they are worked at a boiler pressure of 160 lbs. per square inch, we may assume that for a short run an effective cylinder pressure of 130 lbs. per square inch could be maintained. Under these circumstances the engine would exert a tractive force of $100.5 \times 130 = 13{,}065$ lbs., and would develop $13{,}065 \times 2{,}016 = 26{,}339{,}040$ foot-pounds of work in ascending the incline. Subtracting this from the total amount of work to be done, as determined above, we get $37{,}665{,}680 - 26{,}339{,}040 = 11{,}326{,}640$ foot-pounds of work as the deficit which is to be made up by the reduction of the speed of the train; and we must now proceed to ascertain from this how great this reduction of speed must be. The total weight of the train is $339 \times 2{,}240 = 759{,}360$ lbs., and dividing 11,326,640 by this number, we find that the deficit to be made up is equal to the lifting of the whole train through a height of $\frac{11{,}326{,}640}{759{,}360} = 14.78$ ft. If, therefore, the train had to merely reach the top of the gradient with no residual velocity, its speed on reaching the foot of the incline would have to be that which would be acquired by a body in falling from a height of 14.78 ft., or a little under 31 ft. per second. In reality, however, the trains have a speed of about 5 miles per hour, or 7.33 ft. per second on reaching the top of the incline; and as this velocity would be acquired by a body in falling through .839 ft., we get $.839 + 14.78 = 15.619$ ft., or, say, 16 ft. as the height corresponding to the velocity which the train should have at the foot of the bank; and the velocity itself would, by the ordinary formula, be 32 ft. per second, or about 21.8 miles per hour.

We have been informed that in practice the speed at which the trains commence ascending the incline is slightly less than we have calculated above, and if this is really the case, the effective pressure on the pistons must be greater than we have assumed, or the friction of the train must be less. A series of indicator diagrams, carefully taken during the ascent of the incline, and accurate observations of the speed of the train on entering and leaving the latter, would give some interesting information which, we think, would be well worth the trouble expended in obtaining it.

The total load of 339 tons, above mentioned, is not the maximum load which the engines have taken up the incline under notice. Mr. Adams informs us that in some instances a load of thirty trucks and two brakes has been taken up, the gross weight of the engine and train in this case being 479 tons. Applying the same mode of calculation to this as to the former example, we get the following results:

	Foot-pounds.
Work to be done in lifting train = $479 \times 2{,}240 \times 41.3 =$	44,318,248
Work to be done in overcoming friction $= 4{,}252 \times 2{,}016 =$	8,572,032
Total	52,885,280
Work done by engine (as before)....	26,339,040
Deficit	26,546,240

This deficit is equal to lifting the whole weight of the train through a space of 24.74 ft., and adding to this .839 ft. as before, we get 25.579 ft. as the height corresponding to the velocity required on entering the bank, and this velocity will thus be, in this case, 40 ft. per second very nearly, or a little over $27\frac{1}{4}$ miles per hour.

VERTICAL WATER TUBE BOILER AND YACHT ENGINE.

From the "Engineer."

We illustrate herewith a very neat boiler and engine for small yachts, patented by Mr. T. Messinger, of Ewell, Kent.

It will be observed that the fire-box is large; it extends to the top of the water tubes, at the same time the bottom ends of these tubes are well down into the flame. The water tubes are placed in a circle round the fire-box, their bottom ends being full open to the side water space, and their top ends full open through the crown of fire-box. A baffle-plate is placed between the tubes, which prevents the flame from at once passing towards the chimney. The flame is thus caused to spread outwards and impinge against the sides of the fire-box, and it envelopes the lower ends of the tubes, striking against them in the best possible manner, viz: at nearly right angles; it is also well split up in passing between the lower ends of the tubes without being extinguished, it then has to pass between the upper parts of the tubes, and before it does so there is ample space between the upper parts of the tubes and the upper parts of the fire-box for the flame to be well expanded, and a second time it strikes the tubes in a good direction, envelopes the upper parts of them in flame, which is well split up a second time in passing between their upper parts. The flame then comes in contact with a coil of copper pipe, through which the feed-water is passing from the pump to the boiler, the water entering cold at the top, in passing down through the coil meets the products of combustion coming upwards; thus the products of combustion, after having twice passed between the water tubes, have to pass from the outside to the inside of this coil and then up through it. The remaining amount of heat is thus well taken up and passed into the boiler in the shape of boiling, or nearly boiling feed-water, and if the boiler and feed-water heater are properly proportioned, the temperature of the products of combustion, before they enter the chimney, will be much reduced; fuel is economized.

It will also be observed that this arrangement of water tubes increases the steaming powers of the fire-box, for supposing these tubes were merely dummies of fire-brick of the same shape, and arranged in the same manner, the heating surface of the fire-box would be greatly improved, as the flame would be more dispersed, and caused to impinge more directly on to the sides instead of merely passing the sides of the fire-box, and going too quickly to the chimney.—Heating surfaces are also more valuable when they are inclined out of the vertical line towards the flame; this is not the case with the fire-box, but it is with the tubes, both at their upper and lower ends. On consideration of the above, it will be seen that all the heating surfaces are exceedingly well disposed to properly receive and transmit the heat to the water, and it was surmised in the design of this boiler that its heating surfaces would be of far more value per square foot than that of other boilers; and the experimental boiler has, we have reason to believe, practically proved this to be correct, for the ratio of fire-grate area to heating surface in this boiler is only as 1 to $20\frac{1}{2}$, whereas in the best locomotive practice it is as 1 to 84. Locomotives having this ratio evaporate from 7 lb. to 8 lb. of water per 1 lb. of fuel, and this boiler, with only one-fourth the ratio of heating surface to fire-grate area, evaporated from 9 lb. to 10 lb. of water per 1 lb. of fuel.

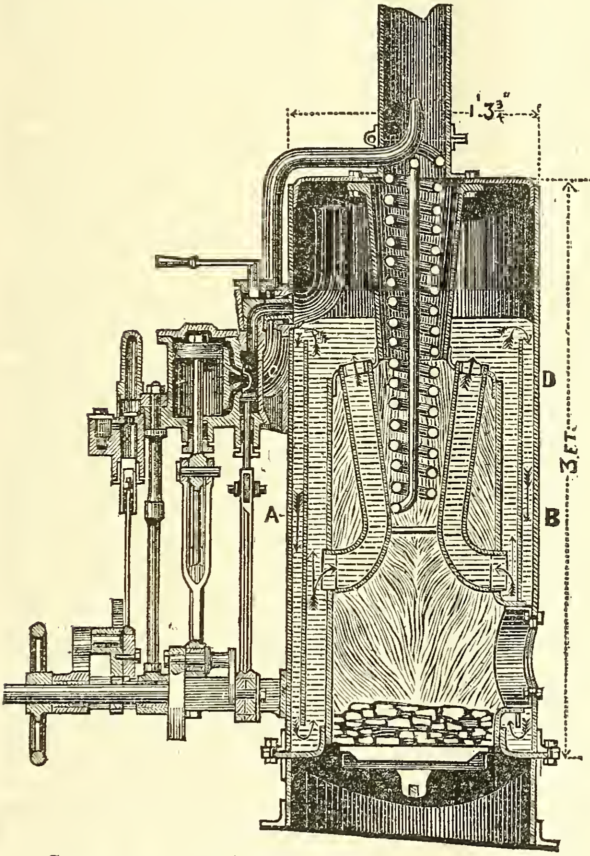
We will now take into consideration the action of the water during the ebullition inside the boiler, and also the generation of steam. It will be seen by the drawing that a cylinder of thin iron is placed in the outer water space, full open at top and bottom; it rests on three legs at the bottom, and is kept in position sideways by a few small distance pieces. This is called the circulating cylinder, because it very greatly assists the natural circulation of water inside the boiler during ebullition. All the water inside this cylinder, both round the fire-box and in the water tubes, being in connection with the heating surfaces, is in a state of violent ebullition. And all the water outside this cylinder, not being in connection with the heating surfaces, is not in a state of ebullition. The water, then, in every part of the boiler inside this cylinder is rapidly carried upwards by the rising bubbles of steam, and, exactly as in a saucepan, tumbles over the edge of the top of this cylinder in a circular waterfall, but it does not, as in the saucepan, tumble over into the fire when it boils over, nor does it commence to prime, but it returns to the bottom of the boiler again down the annular space provided for this purpose contained between the outside of this cylinder and the shell of the boiler, and performs the same circuit over and over again. Therefore there is a rapid upward circulation of water over every part of the heating surfaces, and in the best possible direction, viz: in a line nearly parallel with them, sweeping the clinging bubbles and steam from the plates, and quickly bringing them to the surface, where they readily free themselves from the water into the steam space, and a distinct space is provided outside the circulating cylinder for the return of the water to the bottom of the boiler again.

The arrangement for bolting together is very favorable for cleaning and repairs, especially for small boilers using muddy or salt water. The multitubular boiler generally used for small steam yachts and launches, &c., although generally made to hold a large body of water in proportion to its size, when driven hard is often, in a short time, hopelessly blocked up with scale, and there is no means of getting this out except by the use of strong solutions, which injure the boiler; whereas the boiler illustrated can, in half a day, be taken to pieces, scaled all over by hand, and put together again, and if laid by for the winter, or any other time, may be thoroughly cleaned and tallowed all over inside and out; this will very greatly lengthen its life, for it is often the case that when boilers are laid by for a time they sustain more damage by corrosion than they do when in actual work. The tubes of this boiler having such a rapid circulation of water through them will not give so much trouble by leaking as the fire tubes in the ordinary multitubular boiler do at the fire-box end, and their rapid circulation will, no doubt, greatly reduce the amount of scale deposited on the plates and tubes.

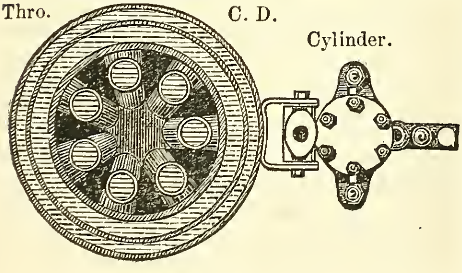
The advantages claimed for this boiler by the inventor are lightness of weight and small dimensions for any given power when compared with any other boiler, simplicity of construction, economy of fuel, small cost of manufacture, and the readiness with which every part can be got at for cleaning or repairs.

The boiler and engine illustrated in the engraving for a steam punt have the following dimensions: Outside diameter of shell, $15\frac{3}{4}$ in.; height of boiler, 3 ft.; fire-grate area, half square foot; heating surface of fire-box, 5 sq. ft; heating surface of tubes, $3\frac{1}{2}$ sq. ft; heating surface of feed-water heater, $1\frac{3}{4}$ sq. ft; diameter of cylinder, 3 in.; stroke, 4 in.; the slide valve, when in full gear, cuts off steam at five-eights of stroke.

Section Elevation of Engine and Boiler.



Sectional plan of Boiler.



During the shop trials, which lasted one month, and were very severe for so small an engine, it was driving a large drilling machine, lathe, shafting, &c., with ease, the engine making 650 revolutions per minute, with a boiler pressure of 50 lbs. Is was impossible to take an indicator diagram on account of the speed, but the dynamometrical power developed in driving a friction brake, was $2\frac{1}{4}$-horse power; and with a consumption of $12\frac{1}{4}$ lbs. of coke per hour, 110 lbs. of water were evaporated per hour, and during the same time with a consumption of 12 lbs. of anthracite coal, 125 lbs. of water were evaporated. This is the average of a number of hours.

The engine, as shown in the drawing, is perfectly self-contained; the cylinder is connected to the framing by an arrangement of three pillars, which take all the working strains of the engine; the brackets by which the engine is attached to the boiler merely have to carry its weight, and the engine can be removed bodily from the boiler and taken all to pieces in a few minutes. As these small engines run at such a high speed, the speed of the pumps is reduced to ensure its regular working by cog wheels, as two and a-half of the engine to one of the pump. In larger engines this gear is not required.

This invention is being introduced by Messrs. Newton, Jenkins & Co., of 4 Westminster-chambers, Victoria street.

THE BIRMINGHAM WIRE GAUGE.

By Latimer Clark.

A paper read before the British Association at Exeter.

In a paper read before the British Association at its meeting in Dundee, 1867, I had the honor of submitting to the members of this section a suggestion to promote the establishment of some universal wire gauge. The gauge which I then ventured specially to recommend, was one approximating very closely to the commonly employed Birmingham wire gauge, and based upon a simple mathematical series, each number representing a weight 25 per cent heavier than the preceding one. Such a scale would, as I then showed, be for a practical purpose sufficiently near to the existing so-called Birmingham wire gauges, as to allow of its being without any inconvenience introduced into trade and manufacture in their stead. At the same time it would always be conveniently reproducible, should ever a reproduction of the normal standard be considered desirable. The history of the present Birmingham wire gauge is as much enveloped in darkness as is the date at which it was introduced, and this is much to be regretted; for had the gauge been determined upon any rational basis, the readiest way would have been to have returned to this basis and reproduced it. In the absence of any definite information, however, to lead us to its origin, it remained only to search in the succession of measures in the gauge itself for internal evidence of the considerations, if any, or at least of the law contemplated or accidental, upon which it was based. In comparing the curve formed by the successive measures of the B. W. G. with that formed by a logarithmic series, it became at once evident, that although very nearly approximate to it, the former measure was not based upon a logarithmic equation, the difference evidently not being one due to difference of constants only. In the logarithmic series, I suggested the relation between the diameters of succeeding makers is throughout as 1 to .8945, whereas in the B. W. G. series, this relation, or if I may be allowed to term it as the factor of reduction, becomes less from .92 in the earlier series, to .82, or thereabout, in the higher ones. At the time from which the B. W. G. probably dates, the manufacturers who then introduced and employed it were not, I think, likely to call in the aid either of mathematical or physical science to supply them with the groundwork of a gauge. Much more probable is it that they took a series of already drawn wires, and constructed their gauge from them.

Before the introduction of steam power, the largest size of iron wire was that now known as No. 1 B. W. G., having a diameter of three-tenths of an inch. From this the next smaller size was drawn at one operation, and from this in turn a still smaller size, until at last the smallest wire had a diameter of a few thousandths of an inch. The most natural way, therefore, by which the wire manufacturers could provide themselves with a gauge would be to call the largest size they could draw No. 1; the next smallest drawn at one operation, No. 2; and so on. In doing so, the relations of the succeeding sizes would be determined between two considerations. On the one hand, the manufacturer would naturally endeavor to draw down at one operation as small as possible, to save labor. On the other, he would be limited in this by the strength of his men, or the machinery in use before the introduction of steam power, and by the cohesive strength of the material itself. Practice would soon show the most profitable mean between these opposing items, and thus the course of manufacture itself would in time supply the workman with a succession of sizes, which he would only need to transfer directly to a measuring plate or calipers, in order to have a gauge adapted to every want of his one individual trade. This I believe to have been the origin of the B. W. G. If this is the case, we should, it is presumable, in investigating the B. W. G. series, find some constant relation between the breaking strength of each wire and the resistance opposed to the draw-plate in drawing it down from its original diameter. Such a relation indeed exists. If we call the diameter of any given number on the gauge D, and the next succeeding one d, the ring section opposed to the draw-plate will be:

$$(D^2-d^2)\frac{\pi}{4}$$

whilst the resistance, R, opposed in drawing by the ring will be:

$$R=r(D^2-d^2)\frac{\pi}{4} \quad . \quad . \quad . \quad . \quad (1)$$

r being the resistance to drawing against each unit of surface. Further, s is the absolute cohesive strength of an unit section of the material. In a hard drawn condition the absolute strength, F, of the wire as it leaves the draw-plate will be:

$$F = s\,d^2\frac{\pi}{4} \quad \ldots\ldots \quad (2)$$

Assuming the relation between the absolute strength of the drawn wire and the resistance of the opposing ring to be a constant one balanced between the item of labor and rapture, say, $\frac{R}{F}=m$; then

$$r\,(D^2 = d^2)\frac{\pi}{4} = m\,s\,d^2\,\frac{\pi}{4}$$

$$d = D\sqrt{\frac{r}{m\,s \times r}}$$

and the factor of reduction, or the relation between the diameter of any wire and that from which it was immediately drawn, would be

$$\frac{d}{D} = \sqrt{\frac{r}{m\,s + r.}} \quad \ldots\ldots \quad (3)$$

The value of s has been exactly determined for almost all substances as their varying qualities and structural irregularites will allow, and is usually expressed as the weight which would rupture a bar 1 in. square. This value is not constant for all sections, being found to increase in some function as the section decreases. Thus a thousand wires, each $\frac{1}{1000}$th of an inch in section, would bear a greater weight than a bar of the metal 1 in. square. The reason of this is, probably, that when drawn out in the form of wire, irregularities of structure which existed in the bar are for the greater part removed, having caused perhaps the rupture of the wires repeatedly in drawing, and the resulting wires having thus been filtered through the draw-plate, are therefore of a superior quality to the bar from which they were drawn. Whatever the cause may be, the fact remains that the co-efficient of cohesive strength of a small wire is greater than that of a large one. Were it not for this we might assume that the value of $\frac{d}{D}$ should be a constant, and the B. W. G. would then be a logarithmic curve. As it is the value of s varying with d, a difference must necessarily be found between the curve representing the B. W. G., and one based upon a logarithmic series. With regard to the value of the natural constant, r, the only determinations, I believe, are those of an Egen, quoted by Mr. H. Thomée in his very valuable paper on gauges read before the Society of German Engineers, in 1866. These determinations are given in the following columns, in which I have converted the resistance from German into English lbs:

						lbs.
1 wire of	248 mils.	drawn down to	220 mils.	required	=	2063
2 "	114	"	101	"	=	400
3 "	101	"	91	"	=	253
4 "	91	"	82	"	=	156
5 "	82	"	72	"	=	164
6 "	72	"	53	"	=	164
7 "	53	"	48	"	=	65

This series of experiments allows us to arrive at an approximate value of the natural constant, r, or the co-efficient of resistance to drawing per square inch of surfaces, as appears in column 6 of the following Table:

No.	D	d	Area of Ring of Resistance.	Force Required	$r=\frac{\text{Force}}{\text{Area.}}$
1	2	3	4	5	6
	mils.	mils.	sq. mils.	lbs.	lb. per sq. in.
1	248	220	×10,290	2063	200,400
2	114	101	× 2,195	400	182,385
3	101	91	1,508	253	167,450
4	91	82	1,198	150	127,162
5	82	72	1,210	164	135,800
6	72	53	954	164	172,125
7	53	38	397	65	138,875
				mean	160,591

Assuming the co-efficient of strength or the cohesion, s, of a bar 1 in. square to be 80,000 lbs. in round numbers, and that this were constant for all sizes of wire, the absolute strength of the foregoing wires would be as follows:

No.	d.	Absolute strength. lbs.
1	220	3041
2	100	641
3	91	520
4	82	422
5	72	326
6	63	249
7	48	145

and the relation of their absolute strengta to their resistances to drawing $\frac{R}{F}$:

1	$\frac{2063}{3041}$	= .678	
2	$\frac{490}{641}$	= .624	
3	$\frac{253}{520}$	= .487	
4	$\frac{156}{422}$	= .370	mean $\frac{R}{F}$=.538
5	$\frac{164}{326}$	= .503	
6	$\frac{164}{249}$	= .659	
7	$\frac{65}{145}$	= .448	

Assuming this mean, .538, to be the probable value of the constant, m, and asserting it in equation, 3, we get the factor of reduction between the two wires.

$$\frac{d}{D}=\sqrt{\frac{1.60591}{9.538\times 80{,}000+160591}}=0.8811.$$

which is about a mean value of the relations throughout the B. W. G. From this agreement it might at first seem obvious that in the above formula if, instead of the mean coefficient of cohesive strength (80,000) we inserted its variable value answering to the various diameters of wires in the gauge, that we should obtain a series of factors of reduction which would give us a perfect reproduction or rectification of the B. W. G. Such would indeed be the case if we could assume any function of variation with any pretense whatever of its being a constant one. It must, however, be recollected that this variation in the apparent cohesive strength is due not to any constant physical property or law of the material experimented on, but solely upon accidental faults in its structure, in fact, upon the badness of its quality, an item which varies in every different sample. The true co-efficient of cohesive strength of any material is, of course, the highest value obtainable for it, being the value nearest to that obtained with a very thin wire. The co-efficient found with larger bars refers not to the material but its faults, and were it not for these faults, wires of all sizes, of the same material, would have the same co-efficient of cohesive strength. The conclusion which we must therefore arrive at is, that the B. W. G. has been formed from a series of sizes of wires drawn from one another, and into which the effects of impurities of metals have entered. Had not this been the case—that is to say, had all the wires from which the B. W. G. series were originally drawn been perfectly pure and homogeneous—there can be no doubt that the succession of numbers would have had a common factor of reduction, and formed, therefore, a logarithmic curve. In reconstructing this gauge, the question forcibly presents itself, are we to allow the effects of accidental impurities in the material to form part of the basis of a widely employed measure; or shall we not rather base it on the assumption of a pure and homogeneous material? An objection might be raised to this, that the origin of the gauge would be limited to the individual properties of a single metal, viz: iron. This is certainly probable, in so far as the origin of the B. W. G. goes; but it would appear that in most metals a constant relation exists between their co-efficients of resistance to drawing out of absolute strength, and this being the case, it becomes probable that had the workers in any other metal determined on a gauge, they would, with the same method, have arrived at the same result.

Karmarsch has given a table of the relative "drawability" of wires of various metals, taking that of hard-drawn steel at 100. Of course this table does not profess to give the exact quantitative values, but it is sufficient to enable us to see that for all the metals contained in it, a constant relation undoubtedly exists between the co-efficients of drawing resistance and absolute strength. I have, therefore, converted Karmarsch's relative values into pounds, by assigning to iron the value usually given it in the tables, and have compared it with the common co-efficient of absolute strength, as follows:

Metal.	Relative "Drawability" given by Karsmarsch.	Calculated Resistance to Drawing, per Square Inch	Absolute Strength.	$\frac{s}{r}$
1	2	3	4	5
Hard-drawn steel...	100	285,000	125,000	.439
" iron...	88	250,000	115,000	.460
" brass..	77	220,000	84,000	.382
Annealed steel......	65	185,000	75,000	.405
Hard drawn copper..	58	165,000	60,000	.363
Annealed brass	46	130,000	57,000	.438
" iron......	42	120,000	56,000	.466
" platinum..	38	108,000	47,000	435
" copper....	38	108,000	49,000	.453
Silver..............	34	97,000	45,000	.464
Gold................	27	77,000	33,000	.428
			Mean...	.430

From values so roughly determined as those given in the second column, the resulting relations found in the fifth column agree sufficiently well to render it a matter of great probability that even a nearer relation exists than that shown here, and therefore that the B. W. G. rectified to a logarithmic series is not confined to the physical properties of iron, but is equally applicable to any of the other metals mentioned.

If the co-efficients of cohesive strength and resistance to drawing were known, and constant magnitudes, nothing would obviously be easier than to construct on the probable basis of the B. W. G. a rational and applicable measure. These co-efficients are, however, so variable with slight differences in the qualities of materials, that the nearest approach we can make to perfection in a scale based upon their relation to each other is by assuming mean values. In the British gauge, which I have had the honor of suggesting, these co-efficients have average values, notwithstanding that I started from a factor of reduction which I assumed only for the reason of its simplicity, as it allows at any part of the scale the weight of the succeeding number to be arrived at by the addition of 25 per cent, and of preceding numbers by the substraction of 25 per cent of the one from which we start. The factor of reduction for diameter being .8945, and the co-efficient of cohesive strength being 80,000,

$$.8945=\sqrt{\frac{r}{.538\times 80,000+r}}$$

whence, $r=172,300$, which is rather higher than the mean value deduced from Egen's experiments. The adoption of some uniform wire gauge has become a pressing necessity of manufacture, and I submit that the B. W. G. re-established on a rational basis, and rectified from the irregularities which have crept into it, partly by want of some recognized standard, and partly by reason of the impurities of the materials from the properties of which it was originally determined, is the best adapted for the wants of the wire gauge. In conclusion, I must call the attention of the British Association to the labor of M. Karmarsch, M. Thomée and M. Peters, towards the establishment of an uniform wire gauge in Germany, whose opinions entirely agree with my own as to the superiority of the English B. W. G. over all the others now in use, and to whose writings I am now indebted for much interesting matter and instructive information on this subject.

THE CLEVELAND ROLLING MILL COMPANY'S STEEL WORKS.—We regret to learn that Mr. John C. Thompson, superintendent of these works, has been compelled, by ill health, to abandon this branch of professional work, at least for the present. He resumes his position in the Croton Aqueduct Department, in New York city. We learn that Mr. Henry S. Nourse, superintendent of the Pennsylvania Steel Works, Harrisburg, is offered and will probably accept the superintendence of the Cleveland Mill.

THE TREATMENT AND UTILIZATION OF SEWAGE.

From the report to the British Association by a commission consisting of the following gentlemen: J. Baily Denton,* Esq., M. Inst., C. E., F. G. S.; Richard B. Grantham,* Esq., M. Inst., C. E., F. G. S., chairman; W. D. Harding, Esq., J. Thornhill Harrison,* Esq., M. Inst., C. E.; J. Benjamin H. Paul,* Ph. D. F. C. S.; Professor Wanklyn, Dr. Gilbert, F. R. S.; Dr. Angus Smith, F. R. S.

Probably one of the most important results of modern scientific inquiry is the general recognition of the fact that attention to the hygienic requirements of towns and populous places has a great influence on the preservation of health and life. Hygienic measures are calculated to prevent disease, and therefore come to be regarded even of more importance than the knowledge gained by two thousand years' experience in the art of medicine. Pure air and water are two of the most essential requirements of all populous places. The removal of water from the surface and from the subsoil by some kind of drainage has been found essential to healthiness of a place; but the thing most of all important in its influence on the sanitary condition of the towns, etc., and as affecting the purity of the air and water, is undoubtedly the mode in which the excretal refuse of their population is dealt with. Even in the most primitive states of society it has always been found necessary to dispose of excreta and other refuse materially from dwellings, in such a manner as to prevent them from becoming a nuisance, and the most simple mode of effecting that object was probably the plan prescribed by Moses to the Jews.

The fact that animal excreta are useful as a manure has also led in many cases to the adoption of some plans of dealing with them for that purpose by which their accumulation in the vicinity of dwellings was prevented to a great extent. In thinly populated places no great difficulty would be experienced in devising simple measures sufficient in that way to meet all requirements, and under such circumstances the mode of effecting the object in view would be a matter to be determined and carried out by the individual residents of a place. But wherever the population became concentrated in villages or towns, difficulties arose as to the disposal of excreta or the immediate removal and use as manure, in consequence of which it became a practice almost universal

* These have only attended the meetings.

to allow them to collect together with other refuse in pits dug in the ground near each house or group of houses, and then at intervals to remove the accumulated contents of these pits for use as manure. As the magnitude of towns increased the difficulty of thus dealing with excretal refuse became greater, and the offensive consequences of its accumulation near dwellings more sensible. Hence the subject became more and more a matter to be dealt with by the local authorities, at first by regulation of the practices adopted by the inhabitants of a place, and eventually as a duty to be provided for and performed by the authorities themselves, in such a manner as to insure the common convenience and well being of the population.

However, the full importance of this subject in other respects was far from being appreciated until within the last thirty or forty years. It is only within this recent period that there has been anything like an adequate recognition of the fact that the sanitary state of dwellings and towns, the health and morality of their population, the condition of rivers, and other matters of importance, are, as a general rule, largely influenced by the practices adopted in regard to excretal refuse. Within that period inquiry and experience have shown that excretal refuse, besides being offensive, and in some cases a great nuisance where accumulated in a state of putrefaction or decay near dwellings, may be, and often is, a source of vast injury to the public health. Opinions may vary as to the precise mode in which that influence is exercised—whether by the evolution of the deleterious gases, by the pollution of water, by the development of those minute organisms which are now very generally considered to be the media of infection, or in all of these ways conjointly; but there is no longer any doubt or difference of opinion as to the general truth that in regard to the mode of dealing with excretal refuse, the sanitary point of view is far more important than any other. If, then, the weightiest question to be solved by a municipal body be—how best to preserve the health and life of the population committed to its charge, it is evident that one of the first duties of such a body is that of providing for the disposal of excretal refuse in a suitable manner. The recognition of this sanitary axiom has been so imperatively enforced during the present century by the frequent prevalence of epidemic diseases, such as cholera and fever, that it may perhaps now be regarded as unquestionable, except where ignorance overcomes intelligence, and where mistaken notions of economy prevail.

Under this aspect the subject has lately attracted very general attention, not only in this country but also in most civilized countries abroad. It will, therefore, be desirable to recite briefly the circumstances under which excretal refuse may become a source of injury to health, and to trace the course events have taken in regard to this subject since public attention was first directed to the sanitary condition of towns, and since measures have been adopted with a view to its amelioration.

Besides the inconvenience and offensive character of the system of collecting excretal refuse in pits or vaults near dwellings, the evils consequent upon that plan arose chiefly from the impregnation of the surrounding soil with decomposing material, and sometimes also from the pollution of water used for domestic purposes. The pit or reservoir was, in some cases, provided with overflow channels or with drains, by which the liquid contents were discharged into a neighboring water-course or into a sewer, but in many cases that was unnecessary, since the soil was of a sufficiently porous nature to admit of the continuous force escape of liquid from the pits. By this natural drainage, according to the nature of the soil, the liquid portion of the excreta would permeate the soil and gain access to the wells, which were, as a very general custom, placed close to the pits where excreta were collected. Moreover, this foul drainage would be augmented, in many cases, by the access of surface water to the pits, especially during wet weather.

These evils were often much aggravated by the absence of any systematic drainage or sewerage of towns sufficient for the removal of subsoil water which became stagnant and putrified beneath the dwellings. Even where underground sewers existed they appeared to have been intended only for the removal of surface water; the connection of house drains with these sewers was prohibited, and it was a penal offense to throw any excretal or other offensive refuse into rivers. At that time the water-closets introduced by Braham, in 1793, were very rarely in use; they had been adopted only in the better class of houses in towns, and then they were used in conjunction with underground vaults for receiving the material discharge from them. Their subsequent more general adoption, and the concurrent acquisition of a better and more copious water supply, were no doubt largely conducive to the health of towns. These changes were attended with a decided aggravation of the evils arising from the use of vaults or pits as receptacles of excreta, for the drainage or overflow from them became continuous on account of the use of water in the closets, and was no longer dependent on the occasional excess of rain. Under these circumstances the pits or vaults became cesspools constantly charged with liquids which in most cases had no outlet into the sewers. Even so late as 1844 the Health of Towns' Commissioners state in their first report that in some of the largest and most crowded towns all entrance into the sewers by house drains or drains from water-closets or cesspools is prohibited "under penalty;" while in other places, including part of the metropolis, the entrance of house drains, was "the concession of a privilege, subjected to regulations and separate proceedings, with attendant expenses," tending to restrict the use of sewers for the purpose of removing excreted refuse or the drainage from pits containing it, or to confine the advantages of this plan to the wealthy.

The removal of the domestic nuisance and inconvenience attending the use of privies and pits for collecting the refuse, by the introduction of water-closets, gave rise in this way to the creation of a town nuisance. The pent-up overflow from cesspools connected with water-closets saturated the subsoil; the town sewers or drains proved inadequate to the duty thrown upon them, for in some instances an improved water supply was taken into a town without any means being provided for taking it out again. The water of wells became permanently polluted; fetid water rose in the cellars of houses, rendering the air impure by its exhalations. Sickness followed, and eventually there arose a louder cry against the cesspool system as an intolerable nuisance, affecting not merely individual houses but the town generally.

The plan proposed as a remedy for this evil was the general introduction of water-closets, combined with a system of thorough town sewerage, the connection of house drains with the sewers being made compulsory on the owners of houses under certain conditions. By these means the necessity for allowing excretal refuse to accumulate at all near dwellings or within towns was to be done away with, and it was to be at once removed from dwellings into the sewers by a copious use of water, and swept rapidly through them out of the town with the waste water from houses and the surface drainage. In this way the water entering a town eventually becomes polluted either by use or by admixture, and thus constitutes what is now commonly termed town sewage, the expeditious removal of which from the vicinity of the town is indispensable for the health of the neighborhood.

This system, known as the water-carriage system, has been largely adopted in this country, and, as a consequence, both the drainage of towns and the removal of the excretal refuse have been in many cases effected by the same means. The utilization of this town sewage as manure by the irrigating of land was contemplated at the outset, but it was not enforced, and it has been carried out only in a few cases, the sewage, as a rule, being discharged from the sewers into any adjoining rivers or into the sea, this being permitted so long as it did not create a nuisance. Individuals or towns injured by the discharge of sewage in this way were left to obtain what redress they could by legal means. The adoption of this system is well known to have given rise to much litigation, and many towns where it has been adopted have been placed in a very difficult position in consequence of injunctions by the Court of Chancery prohibiting the discharge of their sewage. Moreover, the adoption of the water-closet and sewage system of dealing with excretal refuse has been followed by a greatly augmented pollution of rivers, which is now acknowledged to have become an evil of national importance, and is still the subject of an official inquiry. At this point, when the measures adopted for removing successfully the domestic nuisance and the town nuisance arising from the disposal of excretal refuse have given rise to a national nuisance, it has become a very serious matter to determine what is to be done with the sewage of towns. The importance of this question is shown by the fact that besides engaging the attention of the late General Board of Health, besides being frequently discussed in Parliament and by the various local authorities throughout the kingdom, it has, within the last thirteen years, given rise to the appointment of three royal commissions charged with the duties of investigating the subject and of suggesting remedial questions, viz:

(1). The Sewage Commission, dated January 5th, 1857, to inquire into "the best mode of distributing the sewerage of towns and applying it to beneficial and profitable uses," from which three reports have issued, bearing date March, 1858; August, 1861; and March, 1865. The conclusions the commission arrived at were to the effect that the direct application of sewerage to land favorably situated, if judiciously carried out and confined to a suitable area, exclusively grass, is profitable to persons so employing it; that where the conditions are unfavorable, a small payment on the part of the local authorities will restore the balance; that this method of sewage application, conducted with moderate care, is not productive of nuisance or injury to health; that methods of precipitation are satisfactory merely as a means of mitigating a nuisance; that the only radical way of restoring the rivers to their original purity is to prevent the discharge of foul matters into them, and especially the discharge of sewage and other refuse of large towns; that the right way to dispose of towns' sewage is to apply it continuously to land, and that it is only by such application that the pollution of rivers can be avoided; that the magnitude of a town presents no real difficulty to the effectual treatment of a sewage, provided it be considered as a collection of smaller towns.

(2). The Rivers Commission, dated May 13th, 1865, to inquire "how far the present use of rivers for carrying off the sewage" of towns, populous places, &c., can be prevented without "risk to the public health, and how far such sewage, &c., can be utilized," from which three reports have already issued, bearing date March, 1866; May, 1867; and August, 1867; and further reports are expected.

(3). The Royal Sanitary Commission, dated November, 1868, "to inquire into and report on the operation of the sanitary laws for towns, villages and rural districts in Great Britain and Ireland, so far as these laws apply to sewage, drainage, water supply, removal of refuse, prevention of overcrowding, and other conditions conducive to the public health." This latter commission is now engaged in its first proceedings, which are limited to the consolidation and improvement of existing laws, and the establishment of a better recognized central control. It is expected that a preliminary report from this commission will shortly appear.

The object of this committee has been understood by its members as that of supplementing the above mentioned public inquiries with special information as to the local circumstances and practical experience of various towns throughout the kingdom, and with other positive data relating to the subject, such as the Royal Sewage Commission have pointed out as requiring to be ascertained:—"Your committee, on entering on the duties, came to the conclusion that since town sewage, as it is now most commonly known in this country, is a source of nuisance, inconvenience and injury to health, chiefly by reason of its containing the excretal refuse of the population, it was desirable the town sewage should not be restricted to the liquid discharged from sewers in places where there is a thorough system of sewage, combined with water-closets and a copious supply of water, or, in other words, where the water-carriage system of disposing of excretal refuse has been adopted; but that it should for the purposes of the inquiry be understood as comprising excretal refuse in any state." In order to insure an explicit understanding on this point in all correspondence and communications, the following resolution was passed at a meeting of the commission on the 5th of January, 1869, viz:

"That the committee do interpret the word 'sewage' in the instructions of the associations as meaning any refuse from human habitations that may affect the public health—and this interpretation of the term specified in all applications for information. Bearing in mind the circumstances already referred to in the introductory remarks, that formerly towns' sewers were essentially drains, the object of which were simply and exclusively the removal of surface and slop-water by the most direct course to the nearest stream, as well as the fact that such sewers, originally intended only for drainage, have in various ways come to be confounded with and used as sewers for removing excretal refuse, as well as the surface subsoil water, it was for these reasons considered to be especially important to make a marked distinction between drainage and sewerage, and with that object to denote the removal of surface and subsoil water from land by permeable channels, 'as drainage by drains,' and the removal of excretal and other refuse from dwellings, factories, streets, &c., by impervious conduits, or 'sewerage by sewage,' according to the destination, a drain should be understood, or a permeable channel adapted throughout its entire length to remove water from the soil surrounding it; while a sewer should be understood as a channel sufficiently impermeable to be adapted for carrying away refuse without allowing either the refuse to escape through its sides or water to penetrate from without."

One of the first steps taken by the committee was to apply to her Majesty's Secretary of State for the Home Department for his assistance in obtaining information from foreign countries having representatives in England, respecting the practice prevailing abroad for disposing of the refuse of towns, villages, public institutions, factories, dwellings, &c., and having reference to the sanitary condition of the districts in which they are situated, the state of rivers, or the support and increase of the produce of the soil. This application Mr. Secretary Bruce has given effect to by transmitting from time to time very valuable information received from the following countries:—March 15, 1869, from Hamburgh; March 16, from Saxe Coburg Gotha; March 25, from Holland; March 30, from Bavaria; April 14, from Baden; April 26, from Saxony; from Prussia; May 18, from Switzerland; May 20, from Austria and Hungary, from Belgium, from Sweden, from Denmark, from Turkey, from Greece, from Russia, from the United States of America, from Wurtemberg.

It appears from the documents that in most cases, both in town and country places, the use of privies is very general, water-closets being rare even in large towns, and that the usual method of dealing with human excreta is to allow it to collect in pits (*atrills gruben; fossei*), which are sometimes drained, either naturally by the permeable character of the soil, or artificially, so that most or all of the liquid portion of the contents of the pits flows away or infiltrates the surrounding soil. Frequently privies are built over rivers with the object of getting rid of the excreta at once, and at some places methods still more objectionable are adopted, and many houses are without water-closets or privies, and the common custom is to use night-stools, which are emptied into pits near the house. Thus, for instance, in Berlin, with their population under 600,000, there are said to be no less than 50,000 night-stools. Only in some few foreign towns is there any system of sewerage for the removal of excreta by means of water. This is the case with Hamburgh, Paris, Brussels, Hanover, Washington, Philadelphia, San Francisco, and some other American towns to a greater or less extent. In some other towns modified arrangements of the privy and pit system have been to some extent adopted. These consist in substituting for the ordinary pit either a fixed or portable reservoir for receiving the excreta. These reservoirs are sometimes constructed with a drain, by which the overflow of the fluid contents escape, and sometimes they are both water and air-tight, the discharge of the liquid contents into the sewers being prohibited. In some cases such reservoirs are constructed so as to receive only the excreta, and sometimes so as to separate the solid and liquid excreta; but they are also used in combination with water-closets, and sometimes they also receive rain water from the house roofs, &c. The contents of the fixed reservoirs are removed periodically in several different ways, and according to divers local regulations; sometimes their contents are simply dipped out, and sometimes they are removed either by pumping into closed tank-carts, with lift-pumps, or by means of a vacuum previously produced in the tank-cart. In some few cases the time that may elapse between the removal of the contents of these reservoirs is fixed by the local authorities. The portable reservoirs are from time to time removed and replaced with empty reservoirs, then carried outside the town, and their contents used as manure in some way. Both the fixed and portable reservoirs are frequently ventilated by means of shafts rising above the house tops. Fixed reservoirs are used in Carlsruhe, Ostend, Antwerp, Strasbourg, Berlin and Dresden; portable reservoirs are used in Gratz, Dresden, Leipzic, Strasbourg, Berlin and Paris. Generally the contents of pits and of fixed or portable reservoirs are used as manure. In some cases such householders pay for the removal of excretal refuse, in others the contents of pits and reservoirs are sold.

At some places the town authorities pay for the removal of the refuse and street sweepings. Thus in Carlsruhe, a town with about 25,000 inhabitants and 1,400 houses, £500 a year is paid to the contractor for the service, and the contractor sells the manure.

Sometimes a town derives some return from the excretal and other refuse removed and used as manure. In the town of Groningen the yearly profit amounts to about £1,600; in Antwerp it is £2,700; Ostend, £700. In Strasbourg the cost of removal is only just covered by the sale of the manure; the sale of the refuse from the barracks at Carlsruhe, where 2,800 men were quartered, realized a profit of £300 a year, and the attendant expenses amounted to about £40 a year. According to experience in the neighborhood of Berne, Basle, Munich, Zurich, Ghent and other towns where excretal refuse is removed and used as manure, there is always a profit realized after payment of the cost of removal and transport, and it appears to be considered probable that the expenses attending this system would be reduced by the adoption of portable reservoirs. In some other towns the cost of removal and transport exceeds the return; thus in Stockholm, with a population of about 150,000, the expenditure amounts to £35,000 a year, and the income derived from the sale of the refuse as manure £33,000 a year. In Hamburgh there is an extensive system of sewerage, and in a large part of the town the excreta are removed by water-carriage through sewers. In Brussels, Paris, Lausanne and Lugano, the water-carriage system is also more or less in use in some form adapted to local conditions. In the two latter towns water-closets are but rarely used, however, and in Basle, likewise, the privies are situated so as to discharge into the Rhine or into one of its tributaries. In the case of Hamburgh the water of the Elbe is stated to be much polluted by the discharge of sewage, but without any apparent serious influence on health. Statistics furnished by the Secretary to the Hamburgh Board of Health, show, however, that the rate of mortality has kept pace with the increase of population. In 1840, before the construction of the sewerage, the population was 137,000, with a mortality of twenty-eight per thousand. In 1838, the population was 148,000, with a mortality of twenty-two per thousand. In 1859, the population was 174,000, with a mortality of twenty-six per thousand, and in 1866, the population was 195,000, with a mortality of twenty-eight per thousand. The general purport of the communications received from foreign countries is to show that the question as to the means by which excretal refuse may be disposed of and removed from dwellings, villages and towns, so as to prevent nuisance and evil consequences as regards the sanitary condition of the locality, is at least quite as much an open and disputed question as it is in the country. In these documents there is abundant evidence that wherever the subject has been considered there is a strong though vague sense of the injury to health resulting from the accumulation of excretal materials in pits, &c., within populous districts, from the impregnation of the soil, from the pollution of rivers and well water with drainage from such accumulations, and by the discharge of excretal materials into watercourses directly or indirectly; and it appears to be generally admitted that these are serious evils that require to be remedied. Beside these views as to the sanitary aspect of the subject, there is still more decisive evidence of the conviction that a vast quantity of material is now wasted which might be of great service in agriculture for sustaining and augmenting the fertility of cultivated land. There is, however, no instance in which decisive conclusions have been arrived at as to the best mode of dealing with town refuse so as to secure a satisfactory state of public health, and at the same time admit of the agricultural value of that refuse being realized without concurrent disadvantages. It does not appear that any particular improved system of dealing with house refuse has been generally adopted as a substitute for the old practice of collecting such refuse in pits with periodical removal of the contents; neither is there any case where an attempted improvement has been long enough practiced to furnish satisfactory evidence as to the efficacy of the means adopted, and their influence on public health. In both these respects it may be easily said that foreign towns are, as a rule, far behind some towns in this country. The method of removing excretal refuse by pumping it into carts and carrying it out of the towns to the neighboring land, has, in some instances, been continued with satisfaction, while in other instances it has been tried and abandoned. The plan of collecting and removing excretal refuse in portable closed reservoirs has been largely adopted in France, Saxony, Switzerland and other countries, but in no case is any specific information given as to the extent to which the liquid portion escapes spontaneously or by drainage to pollute the adjoining soils and watercourses, or how far the portion of the refuse that remains represents its original value for agriculture. In some towns it is evident that only the solid excreta are used as manure. Thus in Zurich there is a system of sewerage which carries off both the rain-water and liquid drainage from gutters, houses and reservoirs for collecting besides; and probably in most cases where cesspools are fixed and portable reservoirs are in use this greater part of the liquid excreta drains away.

In some towns—as in Berlin for instance—the use of water as a means of transporting the refuse has been proposed, and it is still under consideration. Some of the scientific authorities deputed to inquire into the subject have, however, recommended that any general system of sewerage based on that principle should not be adopted, because of the increased difficulty it gives rise to in the realization of the manure value of the excreta, and because of the anticipated periodical influence on the air of the district where the sewage is applied to land, and upon the water of rivers where the liquid refuse is mixed with them. There does not appear to be in any country general or systematic legislation in reference to sanitary matters; almost everywhere the regulations with that object are in the hands of the police or other local authorities, and though the provisions relating to removals of refuse, cleaning of streets, &c., are often very minute and stringent, they are seldom or ever of such a nature as to deal effectually with those tendencies to unhealthiness which result from the accumulation of excretal and other refuse material, especially in large towns or densely populated districts. As to the precise condition that affects the public health, the connection between the sanitary state of towns and the drainage, water supply, mode of disposing of excretal refuse, &c., there appears to be even more than in this country an absence of definite knowledge or of demonstrative evidence in favor of any particular view; though, at the same time, there is everywhere, in civilized countries, an earnest consideration of these subjects in all their bearings, sanitary, municipal and agricultural.

While this information was being collected from foreign countries, the committee preferred a series of questions with the object of eliciting information as to the several towns, cities and rural districts throughout the United Kingdom, so far as the means at disposal would permit. These questions were sent to 338 local sanitary and sewer authorities, and represent a population of about ten millions. Up to the present time replies have been received from 107 places, having an aggregate population of more than four millions.

Number and population of towns. Town of—	Applied to.	Answered.
Upwards of 100,000	16	8
Between 100,000 and 50,000	23	13
Between 50,000 and 20,000	59	23
Upwards of 10,000	134	33
Rural districts	39	8
Total	338	107

Total area, number of houses, and ratable value of the 107 places from which replies have been received: The total area of seventy-eight of them is stated to be 413,218 acres; the area of the remaining twenty-nine places has not been specified. In ninety-three of these places the total number of houses is stated to be 727,816; and their aggregate ratable value, in fourteen instances no particulars were stated as to this point.

Water supply.—It appears that the sources of water supply in these places are as follows:

	Number of towns.	Aggregate population.
Surface wells	24	354,890
Springs	8	63,680
Gathering grounds	16	1,210,906
Gathering grounds and wells	3	606,552
Gathering grounds and rivers	2	59,000
Rivers and streams	26	843,140
Lakes	1	19,000
Artesian wells	12	263,500
Rivers and surfaee wells	2	446,000
No information given	13	393,740

Of these places, eighty are provided with water-works, twenty-seven without, or give no definite information.

The quantity of water supplied per head of the population is stated to be as under:

	Number of towns.	Aggregate population.
From 50 to 30 gallons	7	596,800
From 30 to 20 gallons	25	1,477,007
From 20 to 15 gallons	13	455,500
From 15 to 10 gallons	15	370,500
Under 10 gallons	3	42,500
Not stated	43	1,444,000

The largest quantity of water supplied is in the case of Lynn, where it is stated to be fifty-six gallons per head daily, and the smallest quantity is said to be supplied in the case of Stroud, where it is only four gallons per head.

Disposal of excretal refuse.—Of the 107 places there are forty-two where the old system of privies with pits for collecting the refuse, is general, and twenty-five where it is partially adhered to. In forty-two places water-closets are general; in twenty-five places they have been adopted partially to a greater or less extent.

Sewage.—Out of the 107 places there are only eleven where no system of sewage exists. In the remainder the sewage of the towns is either general or partial, and in some instances very defective.

	Number of towns.	Houses.	Population.
Completely sewered ..	48	375,002	2,230,578
Partially	48	152,785	1,039,731
Not	11	224,800	145,000
No information	..	....	....
Total	107		

Of the places which are completely sewered there are twenty-nine where water-closets are general, twelve where privies, and seven where both are used. Of the places which are only partially sewered there are twelve where water-closets are general, twenty-two where privies, and fourteen where both are used. Of the places which are not sewered there is one where water-closets are general, six where privies, and three where both are used.

Disposal of liquid sewage and contents of pits, &c.—At seventy-one places out of the 107, the liquid sewage, consisting either of the incharge from water-closets, or the drainage and overflow from pits and cesspools, is discharged into the adjoining stream or river, and in two instances it is discharged into pools of water. At a few of those places the sewage is first submitted to some kind of treatment, chiefly with the object of preventing or mitigating nuisance. At Bury St. Edmunds the liquid sewage is partly got rid of by means of dead wells.

In some places the contents of pits and cesspools are carted away. At fifteen places the liquid sewage is applied to land either wholly or partially, and at two of those places submitted to treatment.

It will be evident that according to local conditions there will be great differences in the nature of the liquid sewage of different places, and that even the contents of pits, cesspools, &c., will vary according as the soil is readily or slightly permeable. The amount of the water supplied, and the admission or exclusion of surface water from the sewer, will also be influenced in this way.

Total quantity and amount of liquid sewage.—Among the ninety-six places where there is a system of sewage, either general or partial, combined with water-closets and a copious supply of water, the minimum daily quantity of liquid sewage discharged varies from 20,000 gallons at Alton, to 17,000,000 at Burmingham, and 130,000,000 at Liverpool.

The storm discharge at places where the surface water is admitted to the sewers, varies from one and a half to twenty times as much as the discharge during dry weather, and in places where the surface water is wholly or partially excluded it varies from one and one-tenth to seven times as much as the dry weather discharge.

The average amount of liquid sewage per head of the population in places where the surface water is admitted to the sewers varies from ten gallons to upwards of 100 gallons, and at places where the surface water is excluded it varies from six gallons to 100 gallons.

Treatment of liquid sewage.—At fifteen of the places which are sewered wholly or partially, the liquid sewage is subjected to treatment either by allowing it to remain for a time in settling tanks from which the deposit is occasionally removed, as at Burton-on-Trent, Birmingham, Epsom, Farnham and Andover, or by filtering, as at Uxbridge and Ealing.

In eight instances deodorizing materials are added, such as lime and carbolic acid, as at Carlisle and Harrow. Lime alone is used at Leicester; lime and chloride of lime at Luton; perchloride of iron at Cheltenham; perchloride of iron and lime at Northhampton; ferruginous clay wetted with sulphuric acid at Stroud; and at Leamington the lime treatment has lately been superseded by the method proposed by Messrs. Sillar and Wigner.

By this treatment the sewage is clarified, and a deposit is separated which is sold as manure.

In regard to the effects thus produced, it is stated that at Leicester the sewage runs off as pure as ordinary rain water; at Ealing it is said to be free from smell, colorless and harmless to vegetable or animal life; at Stroud and Luton the effect is stated to be satisfactory. At Harrow the nuisance is said to be somewhat mitigated, and at Abergavenny the stench is said to be abated by the treatment of this sewage.

At Bury St. Edmunds upward filtration

through charcoal and gypsum has been abandoned in favor of costly irrigation. At Banbury, treatment of the sewage has failed. At Hereford, where it was proposed to be adopted in the parliamentary places, it has not been tried, on the score of expense. At Tunbridge it is about to be tried, and at Hastings and Cambridge experiments are being made.

The cost of treatment amounts, at Leicester, for a population of 7,500, to £300, and the cost of the plant for the purpose was £3,000. At Luton, with a population of 18,000, the annual cost is £500; at Cheltenham, with a population of 36,000, it is £350; at Uxbridge, with 7,000 population, it is £200; and at Alton, with 3,300 population, it is £46.

The solid deposit obtained by treating liquid sewage is sold at prices varying from 6d. to 2s. 6d. per ton. At Leicester as much as 5,000 tons are produced. At Luton the deposit is mixed with night soil, at Banbury with street sweepings, and at Stroud it is made the basis of a manure that is sold at £7 10s. per ton.

After some particulars as to liquid sewage-irrigation, which is carried out in many of the towns of the United Kingdom, the report winds up with the following:

At most places the application of the sewage to land has been found to exercise a most beneficial influence on the condition of the streams and rivers receiving the discharge of the district. At Epsom there was some damage done to the Hogs Mill River, but no complaint is now made. Even where the solid portion of the sewage only is separated by filtration or precipitation, the state of rivers receiving the discharge is improved. At Northampton an application for an injunction has been made by a miller resident on the stream.

Generally speaking, no objection appeared to have been made to the application of sewage for irrigation, and where such objections appeared to have been made on the ground that the application was offensive and injurious, they do not appear to have been supported by medical authorities, and in several instances they have ceased.

As regards the sanitary condition of the district, it appears that in most cases the application of the sewage for irrigation has not been attended with any apparent change, and in several instances there is said to be a marked improvement at Reigate and Brompton. Although the committee feel that the present report deals only partially with the subject of sewage, and is, in fact, only a preliminary step towards the work required to be done, there are two points, viz: the cost of various methods of dealing with excretal refuse, and their influence on the sanitary condition of towns, which it is considered must be referred to, so far as the data obtained will permit.

The removal of the contents of pits and cesspools by cartage appears to be in few instances conducted with some profit; more frequently, however, the cost is at least equal to the return obtained, and very often it is a source of loss. The treatment of liquid sewage does not appear to have advantage in any instance except in lessening the nuisance that would be otherwise caused by the discharge of sewage into rivers, and in most instances it has been a source of loss to the towns where it is practiced. In regard to this point there is a marked difference between the results obtained in this country and those obtained on the Continent, where the removal of the contents of pits is frequently profitable either to individuals or to towns.

The cost of the application of sewage for irrigating land appears to be dependent on a number of local conditions, and, consequently, to vary considerably. It would seem from the data obtained, that in many instances the outlay requisite for this purpose would exceed what a farmer could be expected to incur, and that in such cases at least, it would be proper to regard this outlay as coming under two distinct heads, viz: that which a town may reasonably be expected to bear for the mere object of getting rid of its refuse, and that which a landowner or farmer may be able to incur for the improvement of his land. It is probable that when viewed in this light the application of liquid sewage to land would become a source of revenue to towns only under special favorable circumstances, but that, in opposition to the opinions which have been somewhat hastily formed in certain cases, it will more frequently entail some amount of expenditure on the towns themselves. At the same time the benefit to land and the improvement in the condition of rivers to be realized by the mode of dealing with liquid sewage can scarcely be matter of doubt or uncertainty any longer.

In regard to the sanitary aspect of the subject, it may be regarded as beyond question that the practice of allowing excretal refuse to accumulate and remain for a long time neglected near dwellings in pits, middens, cesspools, or otherwise, is almost invariably accompanied by prejudicial effects on the sanitary condition of the places where it is adopted, either by the impregnation of the soil with decaying material, by the pollution, or by noxious inhalation. But even in places where the water supply has been improved, where a system of sewerage has been adopted, and other measures have been taken with the object of getting rid of the excretal refuse, the fact that the rate of mortality has not been sensibly, if at all, diminished, appears to point to some circumstance as yet insufficiently guarded against, which still exercises a prejudicial influence. The imperfect or defective nature of the sewerage may in some cases be the cause to which this result is referable. But the part of the sewage system which most urgently demands attention at the present time is the ventilation. Gases of a poisonous nature are freely given off from liquid sewage in passages above the sewers from deposits collecting in them and in the house drains. The gases naturally ascend the sewers, and find egress either into the streets of a town or into the dwellings, by means of the house drains and otherwise. The means adopted for getting rid of these gases without injury to the sanitary state of a town, or of the houses in it, are rarely such as to be effective, and the returns already obtained in reference to this matter sufficiently show that attention has not been directed to it in a degree commensurate with its importance. On these grounds the committee consider it would be in the highest degree desirable to institute an inquiry into the nature of the gaseous emanations from sewers in various places.

In reference to the application of liquid sewage to land, they also consider it would be very serviceable to make some inquiry into the nature of the sewage discharged in various places, so as to ascertain the difference that exists in liquid sewage, so far as its value as manure is concerned, and at the same time to endeavor to obtain more definite information as to the cost of removing, and the agricultural value of right as established by practice.

THE FRENCH TRANSATLANTIC COMPANY have contracted to supply their steamers with electric lights. The difficulties of this source of light have been much reduced, and its application looks hopeful.

IRON AND STEEL NOTES.

USE OF STEEL ON THE PENNSYLVANIA RAILWAY.—Steel axles were first introduced, "to secure additional safety," in 1864; and at the end of 1866, 1,907 had been received—600 for passenger and 1,307 for freight cars—the report of their exclusive use under passenger, baggage and express cars, in 1867, being favorable. The number of steel wheels and axles in use during 1868 was 1,042—25 in locomotive trucks, 153 under tenders, and 776 in the passenger and 88 in the freight equipment. Two steel axles out of every hundred are tested under a drop weighing 1,640 lbs., the axle being supported on bearings three feet apart. Passenger axles are required to stand five blows at 30 feet, and freight axles five blows at twenty feet, the axles being turned after each blow.

The use of steel tires was begun in 1861, and in 1866, 62 sets were in use under passenger and freight engines. The first set used ran 103,370 miles (five years' wear) without turning. In 1868, the number used was 327; together with 160 chilled and 15 iron tires, a decrease (217) over 1867, which, the report says, speaks well for the economy of the steel tires. It was early noted that not only are they more durable and safer, but that their adhesive power, even on steel rails, is superior to that of iron tires. On this account they are being tried on the mountain pushers and shifting engines.

The following shows the average mileage per 1-16 inch in thickness wear of tires, on wheels of diameters of 44, 48, 54, 60, and 66 inches:

	44 in. Miles run.	48 in. Miles run.	54 in. Miles run.	60 in. Miles run.	66 in. Miles run.
Krupp steel	......	......	13,550	18,345	20,109
Vickers' steel	......	10,602	20,226	24,640	20,082
W. Butcher steel	......	......	10,284	......	15,605
S. Butcher steel	......	11,603	......	......	......
Camwell steel	......	......	16,743	......	......
Freedom Iron Co. Iron	8,274	5,314	10,684	10,263	......
Lobdell Cast Iron	......	......	......	......	......
Chilled Iron	......	6,547	......	......	......

In the twelfth report (1858) the results of experiments with copper fire boxes were given at length, the difference of cost on copper box being $278 less than that of two iron boxes; while its average duration was five years, in comparison with from three to four years for the two iron boxes. Indeed, the first, put on the road in December, 1852, had been in constant use up to Decemeer, 1858; and 22 new ones were introduced during that year. During 1861, 15 were put in, but as the high cost of copper unduly swelled cost of repairs, and as iron boxes would not answer at all, recourse was had that year to a box constructed of homogeneous cast-steel plates. Their use receives favorable mention in the report for 1863; and in 1866, 76 were reported as in service, not one of which had—whether from cracking, leaking of seams or drawing of stay-bolts—failed in any respect, or exhibited perceptible wear. Their success being complete, no others are now built, the number added, in 1868, being 31.—*Chicago Railway Review.*

Aluminium and its Alloys with Iron.—In regard to toughness, the union of 7 per cent of iron with aluminium can scarcely be distinguished from the latter metal when pure. Both metals easily combine with each other. Commercial aluminium mostly, contains iron; it remains ductile with as much as 10 per cent of copper, and when containing only half as much, it may be worked still easier. If alloyed with small quantities of zinc, tin, gold or silver, the metal is rendered hard and more brilliant, but remains ductile. Especially recommended is the alloy, consisting of 97 per cent of aluminium and 3 per cent of zinc. The alloy with 7 per cent of tin can be worked well, but does not take a very fine polish, and cannot be cast, since a more fusible alloy with a large proportion of tin is separated. Aluminium and lead do not unite. The composition, with 3 per cent of silver and 97 of aluminium, possesses a beautiful color, and in equal parts they yield an alloy of the hardness of bronze. The union of 99 per cent of aluminium and one of gold is, though hard, still ductile; its color is that of green gold. With ten per cent of gold the composition is rendered crystalline.

The Ferryhill Furnaces.—Among the most remarkable objects lately visited by the members of the institution of Mechanical Engineers were the great furnaces at Ferryhill, the largest, as our readers know, yet constructed. The pair, 27 ft. in diameter in the boshers, and 105 ft. high, have been successfully working for the last two or three years, no difficulty being found as to crushing the coke by the height of the columu of materials, nor as to raising the materials themselves by the hydraulic hoists, constructed by Sir William Armstrong and Co.; and at the same time the temperature of the gases at the tunnel head, or rather, under the bell, is, we understand, hardly 500 degrees. The stacks are not supplied with sufficient blast, but their make, as reported to us, is enormous. With an iron stone containing 37 per cent of iron, three casts are made every twenty-four hours, and the daily cast from each furnace is from 75 to 100 tons, or a maximum of 700 tons each per week. —*Engineering.*

Iron Analysis.—Gintl gives a very easy method of determining the impurities in cast iron. It is applied by him to the estimation of the sulphur contained in the iron; but, as will be seen, it is available for the separation and determination of most of the usual impurities. The iron is reduced to as minute a state of division as possible, and is then treated with a strong solution of perchloride of iron, as nearly neutral as possible. The mixture is kept heated for ten or twelve hours, at the end of which time almost all the iron will be found to have dissolved, leaving, as a residue, the carbon, sulphur, phosphorus and silicum, together with the little iron left undissolved. This residue has only to be well washed, oxidized and dissolved, and the sulphur estimated as sulphate of baryta. The exact plan directed by the author is to introduce the residue and filter into a porcelain crucible, having at the bottom three parts of nitrate of potash and one part of hydrate of potash; heat to fusion, dissolve and precipitate with chloride of barium. The phosphorus and silica will be contained in the same solution, and can be determined separately.—*Jour. Franklin Institute.*

An Alloy of Iron and Zinc.—It is a well-known fact that iron is dissolved by molten zinc, but nowhere is any definite alloy of these metals described, nor is it also stated how much iron is dissolved by zinc. Dr. Oudemans, Jr., obtained from analysis a piece of metal which had been formed in an iron vessel wherein zinc had been fused for several weeks continually; this metal was found deposited at the bottom of the vessel, and became an impediment to the melting operations in consequence of the relative infusibility of the alloy. In physical aspect this latter was of very much whiter color, and entirely different crystalline structure from zinc; the alloy dissolved very readily and briskly in dilute sulphuric or hydrochloric acid, and was found, on analysis to contain 4.6 per cent of iron. Taking for granted that this alloy is a definite compound of the constituent metals, its formula would be—FeZ_{36}(F=56 ; Zn32 75).—*Jour. Franklin Inst.*

Iron and Zinc.—It is a well known fact that iron is dissolved by molten zinc, but nowhere is any definite alloy of these metals described, nor yet is it stated how much iron is dissolved by zinc. Dr. Ondemans, jr., obtained for analysis a piece of alloy which had been formed in an iron vessel wherein zinc had been fused for several weeks continuously; this alloy was found deposited at the bottom of the vessel, and became an impediment to the melting operations, in consequence of its relative infusibility. In its physical aspect the alloy was of very much white color, and crystalline structure entirely different from zinc; the alloy dissolved very readily and briskly in dilute sulphuric or hydrochloric acid, and was found, on analysis, to contain 46 per cent of iron.—*Quarterly Journal of Science.*

Crystallization of Iron.—During an examination of the Heaton process for making steel at Langley Mill, Mr. Crookes has noticed a remarkable instance of the crystallization of iron. When the violeuce of the action between the molten iron and the nitrate of soda has subsided, the lower portion of the apparatus, called the converter, is detached, and after a few minutes the coutents are turned out on to the floor in the form of a porous mass of nearly three-fourths of a ton in weight. Upon examining portions of this metallic sponge, it is found to consist of a segregation of minute feathery crystals of iron, apparently built up of small cubes. The outlines of some of these are perfectly sharp, and their appearance, specially in the cavities, is very beautiful.—*Quarterly Journal of Science.*

Improved Blast Furnaces.—The Fraisans Ironworks, near Besançon, have recently received many improvements in the system of construction and in the working of the blast furnaces. The furnaces are 65 ft. high, and 11 ft. 6 in. diameter at the top; they are nearly cylindrical; the diameter is 13 ft. 2 in. only at 12 ft. over the ground. There are eight tuyeres around the furnaces, and the diameter is 11 ft. 6 in. to the level of the tuyere. Up to 12 ft. from the ground the wall of the furnace is made with hollow cast-iron plates inside, through which there is a constant flow of water; the lining of the furnace is made with a single row of fire-bricks, 4 in. thick; the upper part of the furnace is made of riveted sheet-iron; the fire-brick lining is also 4 in. thick, but there is a distance of 2 in. between the sheet-iron and the bricks, and a circulation of air prevents the overheating of these bricks. This arrangement admits of very quick construction, and the body of the masonry being very little it is easily dried; one of these furnaces was in working order three mouths after the beginning of its construction. The daily production of these furnaces is above forty-five tons of pig iron. The ore, which contains 40 per cent. or 45 per cent, of iron, is supplid by rail from a distance of eight miles; the coke comes by canal from St. Etienne, Montchanin, or Epinac—an average distance of eighty miles. The consumption of coke is 18 cwt. for one ton of pig iron. The ore is mixed with 30 per cent of puddling furnace slags; these slags are ground, and mixed with lime and manganese, and then converted into bricks, which are carefully dried and set with the ore in the blast furnace. The silicon of the slag unites itself with the lime, and the oxide of iron is reduced; the slag is prevented from smelting before this reduction. This system admits the introduction of slags in the blast furnace in a much larger proportion than usual. The pig iron seems to be produced at the price of about £2 12s. per ton, which is very low for a district so far from the collieries.—*The Engineer*.

Improvements at Creusot.—A new wrought-iron chimney has been recently erected at the Creusot Ironworks. It is 197 ft. high and 6 ft. 7 in. diameter. At the bottom the diameter is increased to 10 ft. by a curved base, which is fastened by vertical bolts to masonry work. The thickness of the sheet-iron is 3-32 in. at the top, and 7-16 in. at the bottom. There is an inside iron ladder. The weight of this chimney is forty tons; it has been riveted horizontally and lifted afterwards with a crane. Another one, 275 ft. high, will be soon erected, but by a different system; it will be riveted vertically, with an inside scaffolding. These chimneys are built for an extension of the Creusot Works, especially intended for steel-making. There will be eight Bessemer converters, where the cast-iron will be run direct from the blast furnace; there will be also many Martin's furnaces, and an extensive workshop for melting steel in crucibles, where it will be possible to melt together fifty tons of steel. All these new works are surrounded with great mystery, and the admission of visitors is rigorously prevented.

Steel Fire Boxes.—It is stated by the "Iron Age" that the Baldwin Locomotive Works recently ordered 125 tons of steel plates from a Philadelphia maker.

The Pencoyd Iron Works.—These works are located on the line of the Reading railway and Schuylkill canal, about six miles from the city of Philadelphia. The location is one that enables the proprietors, Messrs. A. & P. Roberts, to obtain coal from the Broad Top region, and pig iron from Schuylkill and Lehigh Valleys, at a minimum cost. The works were established in 1852, and the first order, for twelve hammered axles, was received and executed in December, 1852. Finding a number of the railways were using the rolled axle, most of which were imported at that day, the proprietors determined on the erection of a rolling mill, which was put in operation in the fall of 1854, since which the business has been steadily increasing, until it has reached a product of 30,000 axles a year; and they have earned a reputation for their axles, both rolled and hammered, that is second to none in the country.

These Works consume largely of scrap iron, all of which is thoroughly cleansed from dirt and rust by placing it in revolving cylinders, preparatory to piling and rolling. The rolled axles are further improved by having the journals hammered in; after the axle is made, the ends are placed in a heating furnace and brought to a white heat, and then placed under a heavy hammer; this serves to clean and condense the iron, giving a cleaner and better wearing surface.

They have lately engaged in the manufacture of Bessemer steel axles, and are now executing an order of some 200, for the Pennsylvania railway, under a guaranteed test of a drop 1649 pounds, falling 20 feet, the axle to stand five blows, reversing at each blow. The axles are made four feet longer than required in use, to give a trial piece. They are also making bridge bolts, piston rods, etc., of Bessemer steel, and lately rolled bridge bolts for the Philadelphia, Wilmington and Baltimore railway, of this steel, 35 feet long, $2\frac{1}{2}$ inches in diameter. In addition to the axle business, which is their speciality, they manufacture bar iron, bridge bolts, guaranteed to stand 60,000 pounds tensile strain to the square inch, and Pencoyd shafting.—*American Railway Times.*

Qualities of Steel.—Kirchweger gives the following review of various sensible qualities of the different sorts of steel and iron:

Cast-steel shows a fine-grained and most regular fracture, hardens by sudden cooling, contains from 1.5 to 1.75 per cent carbon, and possesses 183 lbs. absolute resistance per square millimeter.

Puddled cementation, or blister steeel, welds and hardens, contains from 0.66 to 0.49 per cent. of carbon; absolute tensile resistance 128–199 lbs.

Bessemer steel is fit for welding, hardens very little, is very flexible, fine-grained in the fracture like cast-steel, and contains from 0.51 to 0.65 per cent of carbon; absolute tensile resistance 111–150 lbs.

Fine-grained iron is fit for welding, shows a fine-grained fracture, does not harden, and contains from 0.51 to 0.65 per cent carbon; tensile resistance between 70 and 117 lbs.

Boiler-plate iron is fit for welding, does not harden, shows a fibrous harsh fracture, and contains between 0.50 and 0.65 per cent carbon; resistance 66 lbs.

These comparative statements must only be taken for what they are—mean deductions from German manufacture.

The Utilization of Blast-furnace Slag.—At the Cleveland Institute of Civil Engineers, Mr. Crossley has recently brought forward some interesting facts and suggestions with regard to the possible utilization of blast-furnace slag. Mr. Crossley states that blast-furnace slag is a compound containing an excess of lime; gray slag contains in 100 parts, and on an average:—silica 38.25, alumina 22.19, lime 31.56, magnesia 4.14, protoxide of iron 1.09, manganese a trace, sulphide of calcium 2.95; but its composition is not uniform, and differs according to circumstances. Several things can be done with slag, though its chemical composition would lead us to imagine that it is almost valueless. It can be converted into paving stones, it can be used to obtain sulphate of alumina, aluminate of soda, and pure silica for the manufacture of porcelain. The author makes known a plan of his own in which the slag, after being pulverized, is treated with hydro-chloric acid, which gives the silica in a gelatinous form whilst the alumina, lime, magnesia and iron are dissolved. The solution is evaporated to dryness, washed with water to dissolve the soluble salts, and the insoluble residue is treated with sulphuric acid, by which means sulphate of alumina is formed, the solution of which may be decanted off; the silica, after washing the water, is left in a pure state. The sulphate of alumina may either be evaporated to obtain the salt in a solid or dry state, or it may be directly used for the manufacture of alum. By this process they will give a product worth 3*l.* per ton, and another worth 7*l.* per ton. Every 100 tons of slag will yield 33 tons of pure silica and 147 tons of sulphate of alumina. In some districts certain of the rarer chemical substances are found in blast-furnace slag, and might be extracted as by-products and sold to the dealers in chemical curiosities.—*The Scientific Review.*

Analyses of Swedish Blister Steel.—Dr. David Forbes has examined cementation steel, manufactured at Sheffield of Swedish bar-iron, and found its constitution:

Carbon, in chemical combination	0.627
Carbon, graphitoid	0.102
Silicon	0.030
Phosphorus	0.000
Sulphur	0.005
Manganese	0.120
Iron	99.116
	100.00

Seyfert, McMannus & Co., proprietors of the Reading Iron Works, employ 2,000 men in their foundry, steam forge, rolling and nail mills, tube works, &c. The rolling mill has a capacity of 5,000 tons per annum; the tube mill about 10,000,000 feet of wrought iron gas, steam and water tubes, besides 3,000,000 feet of lap-welded boiler tubes; 350 tons of pig metal are produced daily, and about 5,000 tons of sheet iron annually. The wages amount to $70,000 per month.—*Iron Age.*

The Bethlehem Iron Company have a strong force at work putting up their new rolling mill in South Bethlehem, which, when finished, will be the largest mill of its kind in the United States. It is to be 400 feet wide by 900 feet long. They intend to manufacture all kinds of railroad iron, and also steel rails. Siemens furnaces will be used exclusively, for both puddling and heating.

ORDNANCE AND NAVAL NOTES.

Small-arm Powder.—The particular point to be attended to in comparing small-arm powders is, which gives the best target—that is, virtually, which is most uniform. A powder which gives the best target will, when tested by the Navez-Lewis electro-ballistic apparatus, be found also to show the greatest uniformity in the velocity imparted to the projectile.

One powder may surpass another, either in incorporation—that is, in the thoroughness with which the three ingredients have been worked together; or in physical qualities—the shape, density and hardness of the grains. Practically, all the best English powders, whether made by Government or by the private makers, are equal as to incorporation. No foreign powders can compete with them in this quality, as may be easily tested by flashing off a few samples of both on a glass plate. The specks of unburnt saltpeter and sulphur which all foreign powders leave on the plate show the imperfect manner in which they have been worked. This arises from the insufficient nature of the incorporating machinery in use abroad, where the powerful iron and stone mills now universally used in this country are unknown. An imperfectly incorporated powder would never shoot strongly or regularly, and would, moreover, foul the piece excessively. The conversion of the incorporated ingredients into grains is the part of the manufacture which most affects the shooting qualities of powder. The only way to effect this is to press the mixture into hard cakes in a hydraulic press, and then crush these into grains between toothed metal rollers. The density and hardness of the finished powders (most important features) depend entirely on the pressing process and on the state in which the mixed ingredients are before being submitted to it; and, although it is impossible to ensure uniformity of results with the present machinery, two powders may be made to agree tolerably closely in these particulars. The grains, after being freed from the dust generated in the granulating process, are glazed or polished by long continued friction together in revolving wooden barrels. If this process affects, to any very considerable extent, the shooting qualities of the powder, it is, probably, not so much by imparting a surface or glaze to the grains as by rubbing them down to a more uniform shape.

The extent to which a little variation in the sizes and shapes of the small black grains which constitute a charge of powder affects the shooting is very remarkable, as every grain takes a different time to burn in proportion to its size and shape. Supposing the density and hardness to be uniform, it follows that, if cartridges could be made up of grains all absolutely alike in these two particulars, absolute uniformity in shooting would be obtained. The delicate modes of proof which we possess afford conclusive evidence in support of this. A minute examination of the ordinary small-arm powder of the service—the "rifle fine grain" as it is called—will show that it is made up of grains which vary very considerably in size. It is, in fact, when finished, sifted out between sieves of twelve and twenty meshes to the inch; it must all pass through the former and be retained on the latter. If a quantity of this powder be taken and sifted on sieves of 12, 14, 16, 18 and 20 meshes to the inch respectively, and if cartridges be made up out of the several siftings and fired against others made up with the powder itself, the former, as a rule, will give very decidedly more uniform results than the latter, and the smaller the size of grain used the higher will be the velocity imparted to the bullet. * * * *

Unless some important alterations be made in the granulating machinery so as to enable it to crush up the pressed ingredients into more even sizes of grain, there is no possibility of obtaining quickly a large supply of powder of very even size. And if one size only be made at a time, it would cost as much for time and labor as treble the quantity containing greater varieties of size of grain. This is enough to account for the high prices such powders must always bear, without having recourse to the supposition that any one maker more than another possesses some important secret which enables him to turn out better powder. There is no article the good or bad qualities of which can be more easily detected, and nothing but an honest expenditure of capital, time and labor, can produce a good article. —*Army and Navy Gazette.*

PROOF OF GUNS.—Mr. Whitworth says of the late trial of the 9 in. Fraser gun, pronounced so wonderful by the British press, viz: firing 19 tons of powder and 124½ tons of shot in 1,114 rounds, that as more than half the rounds fired were with powder charges, only about one-half the most effective charge, and the remainder with three-quarters the charge, while all the shots fired were only two-thirds the best weight for that size of bore, I contend that it was no proper test of endurance, but sheer waste of ammunition.

Mr. Whitworth thus describes his own mode of proof:—It consists in preventing the shot from moving when the powder is ignited, the gases generated by the explosion escaping only through the touch-hole. About one-sixth of the regular powder charge fired in this way gives the same strain to the gun as a full charge fired in the ordinary manner. To prevent the movement of the shot, a screw is cut on the periphery of the gun at the muzzle, and on it is fitted a screwed cap having a solid end. The gun is loaded with a cartridge of the ordinary length, but containing one-sixth of the regular charge, and supported by tin discs in the center of the bore; a flat fronted shot, with tight wads to prevent any escape of gas, and a round steel bar reaching from the shot to the end of the bore, are then introduced, and the cap with the solid end screwed on. The gun is then ready for firing, after which my measuring instrument is introduced into the bore, and any enlargement to the 10-1000th of an inch in extent may be ascertained. If there be no enlargement, the powder charges may be gradually increased, until a slight enlargement has been produced. The real strength of each gun is thus positively ascertained, and this strength I would have recorded and stamped upon each gun. This would give confidence to the gunners, and would act as a check on those engaged in the manufacture. When the ultimate endurance of any particular kind of gun is thus to be ascertained, the regular powder charges, or any less quantity deemed desirable, may be used, the enlargements being recorded after each discharge. A 9-pounder bore gun made of my metal, but reduced 12 in. in diameter, has been so tested, and has had 18 full charges of 1½ lbs. fired from it. The expansion in the bore is now .1903 in., and that of the outside diameter is .0485 in.

THE FRENCH NAVY.—The "Revue Contemporaine" contains an article, by M. Amédée Marteau, on the origin and gradual introduction of armor-plated vessels into the French Navy. After recalling to mind the first attempt in that direction, during the Crimean war, when a few unwieldy iron-clad floating batteries silenced the fort of Kimburn, then the construction of the first armor-coated frigates in France, the Gloire, Invincible, Couronne and Normandie, the author adverts to the first voyage of an iron-clad across the Atlantic, performed in 1862, by the latter when sent over to Mexico with Admiral Jurien de la Gravière on board. It was found that her rolling was fearful, as had been predicted by the adversaries of the system, who reasoned on the principle that her armor would render her top heavy, which, according to theory, must cause that defect. It was in order to remedy it, that her altitude above the water-line was diminished, and her masts were lightened, on her being sent on an experimental trip to the Canaries, in 1863; but quite the contrary effect was produced. At Madeira, a consultation was held on board, which ended in a resolution to try whether increasing the weight above, and diminishing it below might not prove a corrective, in spite of theory; and so it was: about 200 tons of conical missiles were got out from the hold and piled on deck, and this actually diminished the rolling considerably. The old theory has since been proved erroneous by mathematical calculations founded on these experiments. The new principle was immediately carried into effect in the Magenta and Solferino, which received two tiers of batteries, whereby the upper weight was considerably increased, and the vessel greatly steadied. Four turret frigates, the Ocean, Marengo, Suffren and Friedland are now building, and will carry sixteen 11-inch guns. But besides these, a flotilla of corvettes is partly formed, and partly in course of execution. Instead of four turrets, like the frigates, they have two, and carry, moreover, four guns between decks. Each is armed with a spur, weighing twenty-two tons, and is propelled by a 450-horse engine, which, however, may, if necessary, increase its power to 1,800 or 2,000 horse.

THE NEW BRITISH RIFLE.—The 200 Martini-Henry rifles which are about to be issued to the troops for trial will, it is stated, be disposed of as follows: One hundred will be sent to India, to be divided among the three Presidencies; fifty will go to Canada, as the station which, as regards climatic conditions, stands in the most direct opposition to India; and the remainder will be issued to the troops at home. The arms will be fired as much as possible, moved from one station to the other, taken on the march, passed from regiment to regiment, and subjected to as many of the vicissitudes of actual service as can be imitated or produced in peace time. About a million rounds of ammunition will be manufactured for this trial; but we regret to hear that the strengthened or "bottle-necked" cartridge is not yet decided upon, and it will, therefore, be necessary to supply the long cartridge, which is not unlikely to prove somewhat weak on service. The "bottle-necked" or shortened cartridge will, doubtless, be preferred ultimately, and it is unfortunate that some of these cartridges, with arms to match, could not have been issued at the same time as the others for comparative trial.—*Engineering.*

Eads' Gun Carriage.—There is now in construction at Fort Hamilton, a carriage to be worked by compressed air, and it is thought, by engineers who have examined it, that it will prove a success. To secure solidity and durability, and also to provide a sufficient support for the gun and carriage, weighing together over 61 tons, a circular excavation 15 feet in depth was made, and upon the bottom a grillage of timbers, each 15 inches square, was constructed. Then six feet of earth, firmly packed, was placed upon and between the timbers forming the grillage, and upon top of the earth, about five feet in thickness, or 150 tons in weight of concrete was laid, and surmounting this is a granite cap or table weighing 42 tons. Sunken into the granite and fastened to it by ten bolts, $2\frac{1}{2}$ inches in diameter, and reaching up through from beneath the grillage, and ten bolts of the same diameter reaching through the granite only, is the bed plate, weighing four tons. Resting upon numerous small wheels which revolve upon a circular track in the center of the bed plate, is the gun carriage, an ordinary triangular-shaped affair substantially built. Projecting from the rear, and underneath the carriage, is an iron arm which is securely bolted to a piston rod working in a cylinder. The cylinder is filled with compressed air supplied from a hydraulic pump, worked by a small steam engine, the pressure in the cylinder being 400 pounds to the square inch. When the gun is fired the recoil is received in this cylinder, and upon the compressed air, by means of the piston rod connecting with the gun carriage. The pressure of the compressed air, it is expected, will check the recoil, and throw the gun forward to its place, or by the use of a lever it can be held back until it is loaded. Surrounding the gun, and with an inclination toward the muzzle, is a wrought-iron apron, upon the top of which is a track or groove, in which the balls or shells are placed, the inclination of the track forcing them around directly under the muzzle of the gun. At this point the ball drops upon a frame bolted to a piston rod working in a small cylinder. The piston rises, carrying the ball with it, until it is opposite the muzzle, when, by an ingenious arrangement, the frame holding the ball is tilted over, and the ball rolls into the gun. This cylinder is bolted to the gun carriage, and is, of course, always in position to raise the projectile. The gun being revolved, run forward, and the principal part of the loading done by the aid of compressed air, but little remains to be done by hand, and the inventor is confident that the gun can be loaded and fired six times a minute, or more than thirty times as fast as by the present mode. If the invention is a success, the advantages accruing from it will be inestimable in a military point of view, and the principle can be applied to ships-of-war, or, in fact, to any or all heavy guns in whatever position they may be placed. The carriage is being constructed upon the designs of Capt. Eads, under the immediate supervision of Mr. Wm. Lane, engineer in charge of Fort Hamilton, and he expects to have it ready for use within a week.—*Tribune.*

A New Explosive Material.—The following account of a new explosive material is abridged from the "Kölnische Zeitung," May 19th, which gives the "Militär-Wochen-Blatt" as its authority: "It is now some time since the proprietors of the Nora-Gyttorp Powder Mills obtained a patent in Sweden, for the discovery of the so-called 'ammonia powder,' a substance which has hitherto been only employed in a few mining districts, but which otherwise seems wholly unknown. Its explosive force may be compared to that of nitro-glycerine, and, consequently, far surpasses that of dynamite. It cannot be exploded by a flame or by sparks, and the explosion is effected by a heavy blow from a hammer. Blast holes loaded with this powder are exploded by means of a powerful cap, or, better, by means of a cartridge containing common powder, for this forms a more reliable exploder. One of the useful and important properties of this new powder is, that it does not require heating in cold weather, whilst nitro-glycerine and dynamite must first of all be warmed, and this has been the cause of many accidents." The same paper further adds: "According to information we have received, ammonia powder was discovered by the chemist, Norrbin." The German "Building News" contains extracts from a report of the Prussian architect, Steenke, who makes the following remarks upon the safety of ammonia powder: "Experiments were made by fastening a lamp to a pendulum, which was caused to oscillate; gunpowder, gun-cotton, nitro-glycerine, and dynamite, all took fire as the flame passed over them, but the ammonia powder did not begin to burn till it had been touched by the flame twenty times. In making experiments upon the force of the blow required to explode it, it was found that, with the apparatus employed, where the fall of a weight from 4 to 5 ft. would explode gunpowder, nitro-glycerine only required $1\frac{1}{2}$ to 2 ft., dynamite $2\frac{3}{4}$ to 3 ft. fall, whilst a fall from 12 to 15 ft. was necessary to cause the explosion of the ammonia powder."

Gun Cotton.—At the Cambridge meeting of the Association in 1862, a committee, consisting of representatives of the mechanical and chemical sections was appointed for the purpose of investigating the application of gun-cotton to warlike purposes. At the Newcastle meeting in the following year this committee presented their report. It was felt that a complete study of the subject demanded appliances which could be obtained only from our military resources, and at the Newcastle meeting a resolution was passed recommending the appointment of a royal commission. This recommendation was adopted, and, in 1864, a commission was appointed which was requested to report on the application of gun-cotton to civil as well as to naval and military purposes. The committee gave in their report last year, and that report, together with a more recent return relative to the application of gun-cotton to mining and quarrying operations, has just been printed for the House of Commons.

A substance of such comparatively recent introduction cannot be fairly compared with an explosive in the use of which we have the experience of centuries. Yet even with our present experience, there are some purposes for which gun-cotton can advantageously replace gunpowder, while its manufacture and storage can be effected with comparative safety, since it is in a wet state during the process of manufacture, and is not at all injured by being kept permanently in water, but merely requires to be dried for use. Even should it be required to store it in the dry state, it is doubtful whether, with the precautions indicated by the chemical investigations of Mr. Abel, any greater risk is incurred than in the case of gunpowder. In the blasting of hard rocks it is found to be highly efficient, while the remarkable results recently obtained by Mr. Abel leave no doubt of its value for explosions such as are frequently required in warfare. General Hay speaks highly of the promise of its value for small arms; but many more experiments are required, especially as a change in the arm and mode of ignition require a change in the construction of the cartridge. In heavy ordnance, the due control of the rapidity of combustion of the substance is a matter of greater difficulty; and though considerable progress has been made, much remains to be done before the three conditions of safety to the gun, high velocity of projection, and uniformity of result, are satisfactorily combined.—*Prof. Stokes, British Association.*

The Palliser Gun.—Some particulars are to hand relating to the practical working of a number of guns converted upon Major Palliser's system, and which will prove interesting to our readers. In 1866, eight cast-iron 24-pounder and 32-pounder smooth-bore guns were converted by Major Palliser into 56-pounder and 64-pounder rifled guns, with a view of ascertaining whether our large stock of cast-iron guns could be advantageously converted into rifled cannon. Of these eight experimental guns one was tested for endurance, by firing continuously, with shot of 64 lbs. weight, until it had completed 2,285 rounds, of which 2,170 were with 8 lbs. charge, eighty-eight with 14 lbs., two with 12 lbs., one with 10 lbs., and twenty-four with 16 lbs. and 86 lbs. shot. The power of endurance of the converted guns was thus thoroughly proven. Six of the remaining guns were issued for service to home and foreign stations, in order that the Royal Artillery might have an opportunity of practicing with them. The preliminary reports from these stations have now arrived, and are, on the whole, very satisfactory. The 64-pounder issued to Devenport has fired over 300 rounds, the gun is reported to be perfectly serviceable, and no complaints have been made of any difficulty in working. The Sheerness 56-pounder gun has fired 200 rounds, and the practice is reported as excessively accurate. The report from Gibraltar speaks in high terms of the accuracy of the 56-pounder issued to that station. The gun has fired 400 rounds, and is perfectly serviceable. The 56-pounder issued to Malta has fired 250 rounds. At Dover a 64-pounder has fired over 180 rounds with remarkable accuracy. The gun is spoken of as being, for handiness and fitness for rough work and exposure, in every way equal to the old 32-pounder. The 64-pounder on board the "Excellent" has fired over 480 rounds with great accuracy, the working of the gun carriage, &c., being in every way satisfactory. These reports are of much interest, proving, as they do, that the converted 64-pounder gun is fully equal to the more expensive wrought-iron gun of the same caliber.—*Mechanics' Magazine.*

Light Guns for India.—The Indian field equipment committee have recommended the adoption of the modified French rifling in place of the Woolwich rifling originally proposed. It will be recollected that two riflings were in competition—the first being a modification of the French groove suggested by Colonel H. Maxwell, Royal Artillery, superintendent of the gun factory at Cossipore; the other that form of groove known as the "Woolwich." The French groove gave slightly better accuracy and a somewhat lower trajectory, but it was thought that the wear of the guns, after continued firing, was somewhat greater with the French rifling. And as the question of wear is one of importance, the committee, in their preliminary report, recommended the Woolwich system; but when the two guns came to be exactly measured to the thousandth of an inch, it was found that the modified French groove had really worn less than the Woolwich groove, and the guns will, therefore, be rifled in accordance with this experience. The question of ammunition is still in abeyance, awaiting the report of the Dartmoor Shrapnel *versus* Segment Committee, but as that report was, we believe, signed on Saturday, the uncertainty on this point cannot be of much longer duration.—*Engineering.*

New British Ironclads.—The following armor-clad ships are now under construction for the Admiralty, either at the royal dockyards or private shipbuilding establishments. They are said to be in such a forward state that they will be completed during the present or early in the ensuing year:—The Sultan, 12, 5,226 tons, 1200 horse power, and the Glatton, 2, 2,709 tons, 500 horse power, double screw turret ship, building at Chatham dockyard; the Iron Duke, 14, 3,774 tons, 800 horse power, double screw, building at Pembroke dockyard; the Swiftsure, 14, 3,893 tons, 800 horse power and the Triumph, 14, 3,893 tons, 800 horse power, building by the Palmer Shipbuilding Company at Jarrow-upon-Tyne; the Hotspur, 2, 2,637 tons, 600 horse power, armor-plated ram, building at the yard of Messrs. Napier & Sons, Glasgow; and the Vanguard, 14, 3,774 tons, 800 horse power, building by Messrs. Laird Brothers, Birkenhead. In addition to the above, the Abyssinia, 4, 1,854 tons, 200 horse power, and the Magdala, 4, 2,107 tons, 250 horse power, double screw iron armor-plated turret ships, are building for the defense of Bombay, the former by Messrs. Dudgeon, at Poplar, and the latter by the Thames Iron Shipbuilding Company at Blackwall. As soon as one of the building slips becomes vacant at Chatham dockyard, a new armor-plated ram, to be named the Rupert, of 3,159 tons, and 700 horse power, is to be commenced at that establishment.—A new armor-plated turret ship, the Devastation, of 4,406 tons, and 800 horse power, from the designs of Mr. E. J. Reed, C. B., has been recently commenced at Portsmouth dockyard.

Submarine Steamship.—The accounts given of the new submarine steamship invented by Otto Vogel sound fabulous, and yet the Berlin *Börsenzeitung* asserts that the Prussian Admiralty has approved of the plans submitted to them for inspection. The vessel, covered with strong plating, is entirely below the surface of the sea, with the exception of the deck, which is surmounted by a vaulted iron roof of immense strength. Beneath this covering heavy guns are placed, so that the whole greatly resembles a first-rate ironclad. It is said, however, that besides all the advantages of such men-of-war, the new ship may be entirely submerged, and in this position is so completely under command that it can outweather a storm or attack an enemy with submarine cannon and torpedoes. Vogel is now engaged in constructing a large model twenty-four feet in length which will soon be finished.

Gen. J. G. Foster, U. S. Engineer, has devised a new and ingenious counterpoise gun carriage.

The following statement of the nominal strength of the armies of Continental Europe was not long since given by Baron Kuhn in the Austro-Hungarian Parliament:

France.	
Army	800,000
Mobile National Guard	550,000
Total	1,350,000
North German Bund.	
Standing army	843,394
Landwehr	185,552
Total	1,028,946
South Germany.	
Standing army	156,760
Landwehr	43,411
Total	200,171
North and South Germany together.	
Total	1,229,117
Austro-Hungarian Monarchy.	
Regular forces including navy and reserves	800,000
Border troops	53,000
Landwehr	200,000
Total	1,053,000
Russia.	
Field army, including army of the Caucasus	827,350
Local forces	410,427
Irregulars	229,223
Total	1,467,000
Italy.	
Army	348,461
Mobile National Guard, including Venetia,	132,300
Total	480,761

Velocity of Shot in Guns.—A series of experiments has been carried on during the last few days at the proof butt, Royal Arsenal, Woolwich, with instruments invented by Captain Noble, late of the Royal Artillery, and now one of the firm of Sir William Armstrong & Co., at Elswick, to measure the velocity of a shot while on passage in the bore of a gun when fired, and also to test the strength of gunpowder. The results of the experiments are not yet made known, but it is anticipated that they will materially alter the data upon which theoretical calculations are made in gunnery.

Improved Cartridges.—A great improvement has been effected in breech-loading cartridges, by the Colt Firearms Company, by which the cartridge case can be reloaded and capped after firing, thus utilizing the same case a number of times. At the Frankford Arsenal the machinery for making the cases has been so much improved as to rival, in precision and automatic character, the machinery of the pin factory, or the mint, besides greatly reducing the cost.

RAILWAY NOTES.

Uniformity of Design and Style in Machinery of the Pennsylvania Railway.—This is now the inflexible rule in every department and class of equipment and manufacture. The reform in this respect, begun ten years since in the car department, now extends to, and is very nearly realized to all the departments of the road. The end arrived at was, as then explained, "to get our entire equipment in each class uniform;" and what particularly commended it was, that it would dispense with a superfluous variety of patterns and duplicate work on hand for repairs. A larger view of late has presented itself, expressed by the superintendent of motive power and machinery, in his report for 1868, who says that its importance, "both as a measure of economy and increased efficiency cannot be too highly estimated; for, with such a system only can the cost of repairs of locomotives and proportions of engines out of service be reduced to a minimum." The superintendent of motive power and machinery is assisted by a mechanical engineer, in charge of the drafting room, after whose designs all work is made; and gauges and templets are placed in the hands of all manufacturers for the company, with drawings of every portion, even to the seats for firemen and engineers in locomotives. As old stock wears out, it is cut up; and the numbers re-appear on "standard" engines and cars of uniform pattern throughout. No deviation is permitted, at any one's will or caprice; all changes must be adopted generally. The system is not a novel one; it is only peculiar to the road in the extent of its application. When the new car shops are completed, the company will manufacture all its own cars; and the time is not distant when it will replace all failing engines, and make all necessary additions to motive power, after a system equally comprehensive. Indeed, it is calculated that in five years, instead of the *forty* different classes of engines now in use (456 at this writing; additions every week), there will be but *three* main classes—standard 8-wheel passenger, standard 10-wheel freight, and standard shifting.—Each of the first two classes will have a "modification," the difference, however, consisting only in the diameter of the driving-wheel and the size of the boiler. An obvious result of the system will be the fact that many of the most important pieces of car or engine, being common to their class, will be *interchangeable*—in locomotives, for example, among castings, the driving-boxes, eccentrics, eccentric straps, etc., etc. The standard locomotive of the road is no less admirably adapted to its work and condition in style than in construction. Devoid of all the brass ornaments with which with superfluous outlay it is customary to overload engines; painted a plain black, with number in gilt and a few neat gilt traceries, it is easily kept clean and its entire look is in keeping with the character of its work. The engineers who at first parted reluctantly with the brass and the fancy painting would not now have them back. Their mistresses are admired not for adventitious charms, but for unpretentious, solid worth; for the relations "she" sustains to her lord and master are by no means without the refinements of sentiment and affection.—*Chicago Railway Rev.*

The Projected Tunnel Railway Under the Mersey to connect Birkenhead with Liverpool, for which powers were taken in a bill this session has been abandoned for the present.

THE MISSISSIPPI BRIDGE AT ST. LOUIS.—Work on the Mississippi bridge at St. Louis is being rapidly pushed forward. The shore pier on the St. Louis side has been completed to a point above low water mark, and the dredge boats are now employed in preparing for the sinking of a caisson for the second pier, which will be located about three or four hundred feet from the shore. The bed rock has been sounded. In order to hasten the completion of the bridge, a large body of workmen is engaged on the Illinois side, digging for the location of the final pier, and within two or three weeks the second pier in the water and the fourth pier on the Illinois side will be under way. The most difficult pier to construct is the third, near the center of the stream, owing to the rapidity of the under current and the sloping character of the bed rock. Engineering skill will, however, overcome all these obstacles, and as soon as the second pier is under headway the caisson will be sunk for the central one. The levee for several squares is covered with stone, brick and timber, which are being prepared for their respective positions. The estimated final cost of the structure is $7,000,000, $4,000,000 of which have already been raised. As the work progresses, there is no doubt but the Legislature, city council and county court, will render sufficient aid to complete the affair at an early day. The rapid currents, quicksand bottom and other difficulties, incidental to spanning a great stream like the Mississippi, will necessarily prolong the work, but that within three years at the furthest the bridge will be duly inaugurated, there can be but little doubt. Capt. Eads, the chief engineer, is laboring with enthusiasm and energy.—While in Europe he visited all the bridges of note, and secured translations of the reports of various civil engineers on the subject of bridge building, with a view to employing in the construction of the bridge the most approved plans, so as to secure a work that will not only be a model of beauty, as far as engineering skill is concerned, but durable as well. Associated with him is Henry Flad, a gentleman who ranks deservedly high among practical and scientific engineers. Both are confident of completing the bridge in three years at the longest, and even talk of two years as the most probable time. The work of tunneling Washington ave., St. Louis, will not prove as difficult a task as many suppose, and it is believed that it can be accomplished without disturbing either the sewer, water, or gas mains. Should this operation, however, prove too hazardous, then an elevated railway will be constructed. In either event the road will terminate in a grand union depot somewhere near Fourteenth street, forming a direct connection with the Pacific and other roads.—*St. Louis Times.*

THE BOILER WATERS OF THE PACIFIC RAILROAD.—There are very few railroads which are so located that good, fresh water for making steam is accessible. In the course of the long stretch of the Pacific Railroad, all the varieties of water which are annoying to engineers have been met with, and there is little doubt that the experience with these waters will prove of great value to the world. The table herewith presented exhibits the saline composition of the water at nine successive locomotive stations on the Union Pacific Railroad, the stations being from ten to fifteen miles apart. The analyses were made at the editor's laboratory, and are as complete as the small quantity of material used in the work would allow. It was impracticable to determine the contents of gases and organic matter. An examination under more favorable cricumstances will shortly be made, and it is confidently expected that in some of these waters a notable amount of the rare alkali metals may be found. The names at the top of the table designate the stations as represented on the railroad time-table.—*Chemical News.*

	Green River.	Rock Spring.	Point of Rocks.	Black Butter.	Bitter Creek.	Red Desert.	Washakie.	Separation.	Rawlings.
Sulphate of soda........	13.37	431.13	57.30	38.64	45.70	106.61	167.79	107.73	28.49
Sulphate of potassa	2.31	....	....	10.71	....	3.78	....	24.64	....
Sulphate of lime........	3.01	354.76	25.41	12.60	23.10	17.99	73.08	178.15	24.15
Sulphate of magnesia........		258.51	1.96	....	....	5.67	35.49	80.08	....
Chloride of sodium........		285.25	17.15	....	18.20	....	5.74	....	28.84
Chloride of potassium	3.64	284.55	32.90	7.21	25.55	2.17	23.38	23.66	5.11
Carbonate of lime........	2.59	....	....	3.01	....	....	....	....	6.65
Carbonate of magnesia........	3.98	....	15.82	15.68	52.29	....	....	41.72	8.05
Silica........		1.05	6.30	....	....	....	.63	3.08	....
Alumina and oxide of iron........		5.67	....	....	....	....	.35	....	....
Residues, per gallon	28.84	1,620.92	156.87	87.85	164.85	136.22	306.46	459.06	101.29

LIGHT ROLLING STOCK.—It has now been indisputably established that it is possible to construct a combined engine and carriage capable of accommodating 66 passengers, of both classes, the whole weight of which, fully loaded, shall not exceed, if indeed it do not fall short of 20 tons, while the adhesion weight is nearly half as much, or ten tons, and the average steam tractive force at least half a ton. The resistance of such a carriage at 20 miles an hour upon a level, would not exceed 300 or 400 lbs., nor, upon a gradient of 1 in 60, more than from 1,050 lbs. to 1,150 lbs., the whole actual work done being, say, 25 horse-power in one case and 75 in the other, or, supposing the speed on the gradient to be diminished to 17 miles an hour, to but 50 horse-power. The carriage is not one of the omnibus kind, but has seven compartments and guard's van, in all respects in conformity with the standard rolling stock of English lines. The weight per wheel being in no case greater than 2¼ tons, lines of corresponding lightness would serve as well as heavy lines now serve for heavy engines, loaded as they are to from five, six, seven, and even eight tons upon each driving wheel. If even half filled with passengers, such a carriage at ordinary fares would earn about 5s. per mile, and, if filled, of course, twice as much. The whole cost of working would certainly be small. When working upon moderately easy gradients, the consumption of coal would run but from 6 lbs. to 8 lbs. per mile, the wages of driver, stoker and guard, making 100 miles a day, to but 1¾d. per mile, and repairs to probably less than a pound a day, or 2¼d. per mile, these respective expenses being thus only 5d., or say, 6d. per mile, including all train charges. Permanent way, station expenses, and general charges might carry the whole to 1s. or 1s. 3d.; but even at twice the last named cost there would be a high proportion of profit on the work.

The motion of the carriage is easier than that of an ordinary train, the total wheel base being so much longer and yet so much easier from being formed upon swivelling bogies. It is almost impossible to imagine that if branch line and other short traffic passengers were allowed to make use of this carriage, they would not universally pronounce in its favor. Mr. Fairlie, the designer, having worked out his system upon the great scale, and with the most perfect success, as the experiments at Hatcham have abundantly shown, is not only to be congratulated, but is entitled also to the warmest thanks of the whole railway body politic.—*Engineering.*

Oscillation of Railway Trains.—Sir Charles Fox says in the "Times": The oscillation of railway trains, more especially at high velocities, producing what is ordinarily called "gauge concussion," is a very serious source of wear to the permanent way and rolling stock of railways, and, as a consequence, of great expense, to say nothing of the discomfort it occasions to passengers, and is, in my opinion, caused in very great measure by the use of wheels, the tires of which are portions of cones instead of cylinders.

If the English engineers would use the swing beam on their railway vehicles, they would be much less troubled from this cause.—*Ed. V. N. M.*

The Mont Cenis Tunnel.—The underground works of Mont Cenis are carried on with increasing spirit and energy. The opening of the great tunnel for the locomotive before July, 1871, is confidently predicted. The Italian minister of public works is hastening the construction of the railway from Susa to Bardonnêche, the southern opening of the tunnel; a guaranty, it is understood, being given that the grand opening will be completed, and the whole properly walled and strengthened by the time this railway is finished. The French government has given similar pledges as to the northern opening at Modane.

Railway Casualties in 1868.—The complete official tale of casualties to human life and limb on all the railways of the United Kingdom, during the twelve months ending with December last, is 212 killed and 600 injured. But among the killed eight suicides are counted for which the railways cannot be deemed responsible—unless, indeed, the eight unfortunates were shareholders. Making this deduction, we have 204 deaths. This, however, is under the mark, but how much under the return of the Board of Trade offers no means of estimating; it tells us only that the statement of "accidents to servants of companies or of contractors cannot be looked upon as complete, as many railway companies (not being required by law) do not report to the Board of Trade every accident which may have occurred to this class of persons." Nearly all the recorded injuries and about two-thirds of the recorded deaths fall under, with reference to the sufferers, two broad and opposite categories—accidents from causes over which the sufferers had no control, and accidents from causes originating in the misconduct or carelessness of the sufferers. The other deaths, about one-third of the whole, are classed without specific regard to these conditions.—*Engineering.*

The Thames Tunnel, which opened on the 2d of August, 1843, was closed in July last, having been a public footway for a period of twenty-six years, less thirteen days. It has been purchased for £200,000 (one-third of its cost) by the East London Railway Company, which line will be completed, as far as Wapping, in a short time. The new Thames Subway from Tower-hill to Bermondsey (Mr. Barlow's scheme), commenced on 16th of February of the present year, is proceeding very rapidly, and, if all goes well, will be opened for traffic in three months time. Its cost will be under £20,000. The works of the old Thames tunnel were commenced in 1825. Physical and financial difficulties delayed the opening for eighteen years.

The Dusseldorf Bridge.—The great railway bridge over the Rhine, near the village of Hamm, a little above Dusseldorf, is progressing rapidly, and will probably be completed before the end of November. The bridge is to consist of four arches, the upper part of which will be made of iron. The iron work of each arch will weigh 14,000 centners. The bridge is united to the main line on the left bank by a viaduct consisting of fifteen stone arches, but this viaduct does not immediately join the bridge; it is separated from it by a revolving drawbridge, so that the line can be rendered impassable at any moment. On the right bank a fort is being built which will command the whole bridge.

A Rapid Change of Gauge.—In Missouri, last month, the Missouri Pacific Railway, a road nearly 200 miles long, changed its line from the broad to the narrow gauge. Nearly 1,400 men were engaged in the work, and they labored with such celerity that the task was accomplished in twelve hours, and without interrupting the business of the road.

Boutet's Bridge.—A site for the erection of the model of the railway bridge from Calais to Dover, designed by M. Boutet, has been granted, at the Government marble depot, Paris, by the Emperor's minister of the imperial household.

NEW BOOKS.

Machinery and Processes of the Industrial Arts, and Apparatus of the Exact Sciences. By Frederick A. P. Barnard, LL.D., U. States Commissioner, Paris Universal Exposition, 1867. Washington: Government Printing Office, 1869. 8vo, pp. 669. For sale by D. Van Nostrand, 23 Murray street, New York.

This is an extremely valuable memoir upon a great number of important topics connected with the Industrial Arts and the applications of mechanical aud physical principles, as these were illustrated in the French Exhibition of 1867. These are considered iu a systematic and exhaustive manner, in fourteen chapters, of which the general headings are: I. The relation of invention to industrial progress, pp. 1–25; II. Motors, pp. 25–127; III. Transmissiou of force, pp. 128–150; IV. Accumulation of force, pp. 151–161; V. Measure of force, pp. 162–168; VI. Direct applications of force, pp. 169–218; VII. Meters for liquids and gas; Boiler feeders, pp. 219–236; VIII. Machines and mechanical apparatus designed for special purposes, pp. 237–280; IX. Processes and Products, pp. 281–332; X. Diving and Respiratory apparatus, pp. 332–346; XI. Improvements in the application of cold, pp. 346–360; XII. Artificial production of cold, pp. 361–402; XIII. Light-house illumination, pp. 403–416; XV. Printing and the graphic arts, pp. 417–468. Under each of these general heads we find grouped a great number of most interesting and important matters, about many of which it is impossible to find elsewhere, if at all, so clear and exact statements. The mere enumeration of the topics thus discussed would fill several pages of this Journal.

The just claims of American skill and science are fully stated, with occasional reclamations, among which we are glad to find under chapter XII, a full recognition of Prof. Alexander C. Twining's American Ice Machiue of 1850, which is unquestionably the progenitor of all similar machines, and which has been most shamelessly pirated and appropriated by European inventors. In concluding his account of Prof. Twining's apparatus, Dr. Barnard adds: "It cannot be too much regretted that an invention of so much merit and importance, and of which the souuduess and commercial value had been so fully demonstrated, both theoretically aud experimentally, should, through the apathy or timidity of capitalists, have been permitted to be neglected in the country in which it originated, till foreign enterprise had seized upon it, and developed it into a great industry."

This Report is illustrated by well-executed wood cuts of the most important forms of apparatus discovered, 154 in number, and is correctly and handsomely printed, under the supervision of Prof. W. P. Blake, charged with editing the Reports of the United States Commissioners of the Paris Exposition of 1867.—*Am. Journal of Science and Art.*

Submarine Warfare. By Lieut. Commander Barnes, U. S. N. D. Van Nostraud, 23 Murray street, New York. 1869.

This is an important book to military men, and consists of an examination of the various offensive and defensive engines that have been contrived for submarine hostilities, including a discussion of the torpedo system, its effects upon iron-clad ship systems, and its probable influence upon future naval wars. Plates of a valuable character accompany the treatise, which affords a useful history of the momentous subject it discusses. Beginning with David Bushnell, who was born in Connecticut in 1742, and was the first inventor of torpedoes, the narrative is brought down to our own day and includes those most famous practical epochs of submarine operations, the Crimean war and our own late struggle. The contrivances of Fulton, and his negotiations concerning them with the French and English governments, are described, as well as the later experiments of Colonel Colt and his cognate proposals to the authorities at Washington. The author regards the Southern States as the first power to introduce a regular system of torpedo warfare. It is, however, certain that the Russians used torpedoes, and even electricity as applied to them, for defending their harbors against the English and French. Fulton thought of this application of electricity, but gave it up as impracticable. The nearest approach to a complete torpedo-boat, in the opinion of the author, is the Spuyten Duyvil, built by Messrs. Wood and Lay, U. S. N. This vessel was not built in season to test her powers during our late war; but Captain Barnes thinks her the most formidable engine of destruction for naval warfare now afloat. A great deal of useful information is collected in his pages, especially concerning the inventions of Scholl and Verdue, and of Jones' and Hunt's batteries, as well as of other similar machines, and the use in submarine operations of gun cottou and nitro-glycerine.—*New York Times.*

A Short Course in Qualitative Analyses, with the New Notation. By J. M. Crafts. Professor of General Chemistry in the Cornell University. New York: John Wiley & Son. 1869.

Familiar with, and rightly appreciating the wants of students, Professor Crafts has prepared a manual as excelleut in design as able in execution. It goes over the whole field that a student would be likely to work in, in a condensed, yet eminently comprehensive and lucid manner. It gives full instruction in manipulation, explicit directions for conducting the various methods of testing and accurate accounts of the operation of the usual re-agents, together with the behavior of the various classes of substances in their presence. The general arrangement of the subject is the best, perhaps, that could be desired for the special aim in view; the divisions are natural; copious references, back and forth, among the different analyses, afford material assistance; while the letter-press itself, with its conspicuous headiugs, is called in to aid the student's progress. The very full tables, at the end, have all the force of diagramatic illustrations. We need scarcely add that the classification, nomenclature and notation are in accordance with latest researches in chemical philosophy. So very convenient, useful and trustworthy a book cannot fail to take and maintain the place it was intended for—at the elbow of the student working in the laboratory. We commend it to the favorable consideration of those engaged in teaching this branch of the science.—*New York Times.*

Bulletin of the National Association of Wool Manufacturers. Boston: Office, 11 Pemberton square.

The Locomotive Engineers' Monthly Journal. August.

A Manual of Machinery and Millwork. By William J. Macquorn Rankine, C.E., F.R.S., &c. London: Griffin & Co. 1869.

This in an entirely new work of Dr. Rankine's, the Regius Professor of Civil Engineering and Mechanics in Glasgow University.

The book is divided into three parts. The first treats of the Geometry of Machinery; the second, of the Dynamics of Machinery; and the third, of the Materials, Strength and Construction of Machinery. Under the head of the Geometry of Machinery machines are considered with reference to the comparative motions only of their moving parts; and rules are given for designing and arranging those parts so as to produce any given comparative motion.

Several problems in mechanism are solved by methods which appear not to have hitherto been published, and which possess advantages in point of ease or of accuracy. Such are those regarding the drawing of rolling curves, and of some kinds of cams; the construction of the figures of teeth of skew-bevel wheels, and of threads of gearing-screws, by the help of the normal section; and some improvements in the details of processes for designing intermittent gear, link motions aad parallel motions.

Under the head of the Dynamics of Machinery, are considered the forces exerted and the work done in machines; the means of measuring those quantities by indicators and dynamometers; of determining and balancing the reactions of moving masses in machines, and of regulating work and speed; and the efficiency, or proportion in which the useful work is less than the total work, in the different sorts of moving pieces, and their various combinations.

Under the head of the Materials, Strength and Construction of Machinery are considered; first, the properties of various materials, as affecting their treatment and use in the construction of machines; secondly, the general principles of the strength of materials; thirdly, the special application of those principles to questions relating to the strength and the construction of various parts of machines; and fourthly, the principles of the action of cutting tools.

The work is illustrated with numerous diagrams. We need scarcely say that any work of Professor Rankine's on a subject such as this cannot but be of great practical value. We have here simply to draw the attention of readers interested in machinery and millwork to its publication.—*The Builder.*

The Metallurgy of Iron and Steel, theoretical and practical, in all its branches, with special reference to American materials and processes. By H. S. Osborn, LL.D., Professor of Mining and Metallurgy in Lafayette College, Easton, Pa., with 230 engravings on wood and 6 folding plates. Philadelphia: Henry Carey Baird, 1869. For sale by Van Nostrand, 23 Murray street, New York.

This voluminous and extensively illustrated work is peculiarly valuable to American readers from the fact that the American practice is so largely described and illustrated. We have heretofore had no book on iron and steel, to any large extent drawn from home sources. While we can now confidently recommend this work to our iron makers, both scientific and practical, we must defer a more extended notice of it until another issue.

Transactions of the Institution of Naval Architects. Vol. ix, 1868, 4to., plates. Published at the Institution Rooms, 9 Adelphi Terrace, London.

This last volume is as good as its predecessors; perhaps, in one or two papers, better than some of the eight volumes before it.

There is one rather formidable evil that besets the character of a large proportion of the papers brought to the annual meeting of this Institution. It is that they are too much hobbies, trotted out by their authors for very practical purposes, no doubt, but these having very often a basis in gold only, the papers are apt to be exaggerative or one-sided; and the politeness of discussions, in which, probably, friends manage to take a prominent part, do not always counteract too favorable statements, much less expose quackery.

There are some papers to which this applies in this present volume—we will not risk the odium of specifying them; but, except in the case of two, we really do not see that any very decisive corrective was even attempted to be applied to statements which, left unchallenged, must lead people astray. There are nineteen papers altogether in the volume; the most ponderous—and, shall we say, puffy?—being that upon the well-worn "turret and tripod systems," and that scientifically the most able and important, being the last in the volume, by Prof. Rankine, "On the waves which travel along with ships." The doubts thrown upon Mr. Saxby's magnetic methods of detecting internal defects in iron, seem to be strengthened by the fact that, after more than a year has since elapsed, we hear no more about it. M. Rochussen's paper on the Treatment of Steel Plates is valuable and worthy of reference, notwithstanding that it contains (p. 8) one astonishing statement, viz: "as the mere cost of *melting* crucible steel, both in England and Prussia, is £9 per ton," &c. We had supposed that M. Siemens undertakes to melt cast-steel in crucibles at a total cost of under £1 per ton.

Were more and abler men of applied science to preside as chairmen at these meetings in place of ancient admirals and lords, the character of the papers would prove higher, and doubtful statements would be more effectually exposed.—*The Practical Mechanic's Journal.*

Scientific Studies, or Practical in Contrast with Chimerical Pursuits. Two popular lectures. By H. Dircks, C.E. Reprinted. Small 8vo. Spon, London, 1869. For sale by Van Nostrand.

In the first of the two of these popular lectures, Mr. Dircks returns to his first biographical love, and the subject of his previous larger and faithfully written biographies, viz: the "Life of the Marquis of Worcester," of 1865, and "Worcesteriana," of pleasant reading and contain some of the biographi-1866. These lectures, slight as they are, form very cal and historical cream of the larger life of the celebrated and wonderful marquis.

It is peculiarly fitting at this time, when another ignorant and self-sufficient parliamentary onslaught has been just made again upon the patent laws, that we should draw attention to Mr. Dircks' work first above given in title. Without venturing to affirm that we can agree in all the author's views as to the rights and wrongs of inventors, we may say that his views are generally full of good sense and clear thought, and that he individually and practically comprehends what he is writing about, when treating of discovery, invention and the proper and improper bearings of the existing patent law upon these. Nothing can better show the real incapacity of such legislators, as the openers of the late debate on the abolition of the patent laws, to deal with the subject, than their confusion of thought as to any distinction between discovery and invention; a confusion, however, from which many inventors' and patentees' minds are not exempt, but which Mr. Dircks labors to clear away. We commend this volume to all interested in patent-law reform, which is urgently needed, and which should be initiated by an effective Royal commission of enquiry commanded to *hear all* pertinent evidence brought before it, and not contrive merely to hear such as shall suit the foregone views of the commissioners, as before now has happened.—*The Practical Mechanic's Journal.*

Practical Mining, fully and familiarly described. By George Rickard. Small 8vo. E. Wilson, Royal Exchange, London, 1869. For sale by Van Nostrand.

This little closely-printed volume, which is pregnantly full of matter, does not belie its title; it is mining, limiting that to British metal-mining, fully and familiarly described, and by a man who obviously has had large experience.

It is, no doubt, impossible to condense into a thin volume of this size, by any process of close type and narrow margins, the whole that can or ought to be said upon so large and so varied a subject, on which much more might be written in the same homely and sensible view as this is characterized by.

But the information given is clear, good and practical, and we do not know a better elementary work to be put into the hands of a lad who has already mastered his schooling and is intended to become a miner; it will at least give him a good panoramic view of what he will be engaged in, and what sort of knowledge he must acquire to succeed as one of that specialized class of engineers called in Cornwall "mine captains."—*Practical Mechanics' Journal.*

Die Hauptheile der Locomotiv-Dampfmaschinen, &c. Bearbt. v. C. Schepp, Civilingenieur, Heidelberg, 1869. 1 vol. 8vo.

In the first part of this work the author clears the table, so to say, by a didactic and critical survey of all the different classes and constructions of locomotives which have got into established use. In the second part he proceeds to construction rules, and deduces *ab origine* the proportions, &c., of all the important parts, including some of the most recent German modifications and improvements of valve gear. It is a very useful book, to the reader of German, for the purpose proposed by the author, "self-study;" the best education that mechanic or any other adult man can ever receive—that which he gives himself; the only one that leaves no fortresses of ignorance in the rear, as all pupil-teaching often does, and as "cram" is sure to do.

Herr Schepp's atlas of plates are excellent and clear engravings, and valuable to the practical locomotive builder, all the necessary dimensions being given in figures, and a special system of cross-lining, now commonly accepted in Germany, is adopted, by which the constructive material of every part is obvious to the eye without the aid of coloring.—*Practical Mechanics Journal.*

Dictionary of Scientific Terms. By P. Austin Nuttall, LL.D. Strahan & Co., 1869.—For sale by Van Nostrand.

At a time when scientific and technical education is so much needed, the issue of a dictionary of terms in use in the practical sciences is timely, and cannot but be useful; more especially a good one, as this seems to be; although, no doubt, within the limits of it there are not a few omissions. Nevertheless, great pains seem to have been taken to render it as complete as possible, considering these limits. The work is preceded by a useful introduction to the classification and study of the sciences.

The Painters' Magazine. Cincinnati: J. Sonnendecker & Co., Publishers, 178 Elm street.

An excellent monthly, containing instruction in the various styles and branches of painting, and also information on the nature and composition of paints.

Inventors and Inventions, etc. In three parts: the Philosophy of Invention; the Rights and Wrongs of Inventors; and Early Inventors' Inventories of Secret Inventions. By H. Dircks, C.E. 8vo. Spon, London, 1867. For sale by Van Nostrand.

MISCELLANEOUS.

Enameling Iron with Glass.—Among the most interesting and beautiful processes of Birmingham industry must certainly be reckoned that of enameling iron with glass, by the patented method of Charles Henry Paris, of France, which was first introduced into this country, A. D. 1850, by Messrs. Selby and Johns, in conjunction with P. F. Griffiths and Co. The enamel is a hard siliceous glaze or covering, formed upon surfaces of wrought or cast iron, so as effectually to prevent any oxidation of the metal. According to a well-informed Birmingham manufacturer it transpires that sea-water, salts, and acids, produce no effect upon it. The process was first applied to the coating of culinary articles, such as saucepans, frying-pans, baking dishes, &c. It is now applied to wash-hand basins, meat dishes, tea-cups and saucers, dinner plates, &c. These articles, owing to their cleanliness and durability, command a large sale in this country. By far the greater part, however, are manufactured for use on board ship, or for the foreign or colonial market. A fall or blow may cause the enamel to chip, but the articles themselves are practically indestructible—a most important consideration where the replacement or breakage is difficult or expensive. Pipes for gas and water service have by this process been enameled to some considerable extent. Upon the introduction of this enameled ware it was usual to coat the articles of a grey color, and owing to their dull appearance the demand for them was somewhat circumscribed. Shortly after the white enamel was introduced with success, as being purer and cleaner in appearance. The printing of the enameled ware succeeded, and soon after Mr. Benjamin Baugh extended considerably the production by introducing enameled iron for door numbers, wagon plates, insurance plates, mill plates, sign, street, and index plates, show cards, door plates, station name plates, gradient plates, &c. By a later improvement elaborate designs are transferred in enameled colors to the surface of the plates, and subsequently burnt in a furnace, thus rendering them proof against atmospheric influence. Finger plates for doors have been manufactured on this principle with marked success, classic figures having been introduced, or sacred imagery, well according with the *Serrure de Tabernacle*. Another feature in the recent improvements is the imitation of engraved zinc plates with remarkable exactness. Enamel has been applied also with marked success to corrugated iron sheets for roofing and small buildings (a *chef d'œuvre* of Wolverhampton product), a purpose to which its capability of resisting the action of the atmosphere adapts it to a remarkable degree. There is little doubt that much greater extension of this and kindred branches of industry is in store.—*Cor. Engineer.*

VELOCIPEDE TRACTION.—A correspondent of "Engineering" says of the bicycle:

Merely looked on as a graceful scientific toy, I think the instrument worthy of consideration, and am sanguine of its being made use of for purposes of travel. If you will grant me the space, I would ask your insertion of the following data from Morin's experiments on traction, and Weisbach's calculations of the work performed by a man walking, and by comparison find the economy in bicycle riding.

Extracts from Morin's experiments on traction on roads, as reported in "Redtenbacher's Resultate," viz: two-wheeled *carts*, having wheels 64 in. and 78 in. respectively, in diameter, and axles $2\frac{1}{2}$ in. diameter, with tyres 4 in. and 5 in. wide:

	For 64 in. wheels.	For 78 in. wheels.
On very good macadam	$\frac{1}{66.2}$	$\frac{1}{82.8}$
On good paved road........	$\frac{1}{86.3}$	$\frac{1}{107.9}$
Parisian paved roads	$\frac{1}{79.9}$	$\frac{1}{99.9}$

Telford's older experiments gave $\frac{1}{71}$ on paved roads, and $\frac{1}{51}$ on macadam; also, I believe, with common laden wagons without springs.

Now for the other side of the question: Weisbach, in his "Ingenieur and Maschinen Mechanik," latest edition, 1865, second volume, page 323, computes the work done in walking on a level road to be equal to the weight of the person multiplied by $\frac{1}{12}$th of the speed per minute.

Now, if we suppose a man to weigh 140 lbs., and to walk at the rate of 3 miles per hour, we should have, by Weisbach's rule, $140 \times \frac{264}{12} = 3080$ foot-pounds per minute as the work done by walking.

I compute the traction for a bicycle to be at the very *outside* $\frac{1}{70}$th when going about 10 miles per hour; for, as a carriage, the velocipede is nearly perfection, and is fitted with a spring, Taking the weight of man and machine together as 210 lbs., and traction at $\frac{1}{70}$th, we should get for the speed of velocipede, when the rider worked up to the same power as when on foot, $\frac{3080}{3} = 1026.66$ ft. per minute, or about 11.6 miles per hour.

I think Weisbach's estimate of walking to be too high, and my own of the traction for a bicycle to be too high also. If we thus estimate walking to be equal to 1820 foot-pounds, and traction at $\frac{1}{100}$th, we get a speed of 10.3 miles per hour for the velocipede. It must, however, be remembered that it takes *months* of practice to *fully* acquire the use of a "two-wheeled horse."

COAL PRODUCT OF GREAT BRITAIN.—The production of coal in Great Britain was, in 1867, according to the returns given in the "Mineral Statistics," 104,500,480 tons. In 1868, according to the returns of the Inspectors of Coal Mines, the quantity was 104,566,959 tons. Of this the exports, according to the returns of the Board of Trade, were as follows:

Name of Country.	Quantity.	Declared Value.
	Tons.	£
Russia	623,767	306,103
Sweden	336,099	162,971
Denmark..................	835,669	367,721
Prussia..................	583,450	239,101
Hanse Towns..............	767,744	346,393
Holland..................	260,048	126,004
France...................	1,925,370	872,492
Spain and Canaries......	524,161	294,248
Italy—Sardinia	288,852	145,590
United States............	103.851	72,046
Brazil...................	293,577	172,393
British India............	542,570	293,203
Other Countries..........	3,752,355	1,957,726
Total	10,837,513	5,355,791

A return showing the quantity of coal raised in and about the coal mines of Great Britain; the number of fatal accidents and lives lost by the accidents, in the year 1868.

Names of Districts.	Number of Collieries.	Quantity of coal raised	Separate fatal accidents.	Lives lost by the accidents.
		Tons.		
Northumberland, Cumberland, and N. Durham...	175	11,400,000	67	69
South Durham............	171	15,300,000	84	87
North and East Lancashire	292	7,053,000	61	65
W. Lancashire & N. Wales	208	7,600,000	126	237
Yorkshire	459	9,705,000	77	80
Derby, Nottingham, Leicester, and Warwickshire...	195	7,699,000	58	60
North Stafford, Cheshire, and Shropshire...........	225	6,000,000	57	61
S. Stafford and Worcestershire..................	550	9,900,000	90	104
Monmouth, Gloucester, Somerset & Devonshire	230	6,200,000	59	61
South Wales............ .	329	9,000,000	100	104
Totals: England & Wales	2,834	89,857,000	779	928
East Scotland.............	254	8,456,084	41	43
West Scotland............	203	6,253,875	40	40
Totals: Scotland........	457	14,709,959	81	83
Totals: England, Wales and Scotland..........	3,291	104,566,959	860	1,011

A CEMENT FOR LEATHER is made by mixing ten parts of sulphide of carbon with one of oil of turpentine, and then adding enough gutta-percha to make a tough thickly flowing liquid. One essential pre-requisite to a thorough union of the parts consists in freedom of the surfaces to be joined from grease. This may be accomplished by laying a cloth upon them and applying a hot iron for a time. The cement is then applied to both pieces, the surfaces brought in contact, and pressure applied until the joint is dry.

Improved Machine Tools.—Mr. John Woolfield, of the Liverpool Works, Soho, who has recently commenced the manufacture of all kinds of machine tools, is introducing some improvements of his own design in connection with lathes. All lathes, up to fifteen inch centers, he fits with hardened steel, conical spindles and bearings. The slide-rest saddle and center-head he fits with steel screws and nut-boxes. In planing machines the advantage of this arrangement is especially obvious, yet it is frequently ignored by makers of first-class repute.—The saddle-slides are so constructed as to protect the screw that moves them from injury or dirt. The surfacing motion is new, good and inexpensive. A referencé to the processes of lathe making will afford some idea of the extreme care required to produce an excellent article. The first process is the boring of the head. Simultaneously, with this operation, the smith forges the spindles and bushes. This is a very difficult matter. First-rate smiths are not always able to produce a sound lathe spindle. The iron is first forged into the required shape, and a piece of double shear steel is welded round it to form the neck or bearing. Should this not be perfectly sound, it is pretty sure to "fly" in hardening. The bushes are steel cylinders, forged of double shear steel, and lapped with the best iron. The welding here is required to be done perfectly.—When these steel bushes are annealed they go to the turner, and turned parallel outside. Then they are subjected to a red heat, and suddenly immersed in running water; and should the slightest flaw occur in the weld, they crack and have to be thrown aside as wasters. If all goes well they are driven into the headstock bored to receive them, and are lapped true and clear, or, in other words, polished by means of a lead lap running at a remarkable speed. The spindle is annealed, then turned, heated to nearly a white heat, and plunged into a stream of water icy-cold. This is a severe trial of the smith's work. The next process is that of polishing. This is effected by placing it in a lathe and causing it to revolve slowly, an emery wheel running at considerable velocity in a contrary direction, until it is highly polished. Thus the spindle is a perfect "fit" when put into the bearings. The slide-rest and saddle are planed perfectly true, and then scraped and smoothed until the various parts, when put tightly together, will slide freely upon each other, a process requiring great care, skill and attention. Caution is especially required in planing slide-rests, beds, &c., lest they should spring when being fastened upon the planing machine. Long lathe beds require especial care. The saddle and bed both require to be scraped true, until they slide freely along the bed from end to end. Great care and nicety of finish is requisite for the leading screw.—In the construction of drilling machines, steel spindles are now superseding those of iron, the latter being liable to bend when subjected to a sudden jerk. Mr. Woolfield has recently patented a corrugating machine, which is estimated to perform ten times the work of the ordinary press, without subjecting the metal to undue strains. There can be no doubt about the glaring imperfections of the ordinary process, both in regard to economy and excellence of workmanship —*Cor. Engineer.*

We would recommend the correspondent of the "Engineer" to visit the Philadelphia tool-building shops. Much of this practice is old, and the use of iron spindles is all out of date.—*Ed. V. N. M.*

Gasholders.—Of the large number of gasholders in and near London, the greater proportion were made in the neighborhood of Birmingham. The largest gasholder in existence, that of 230 ft. diameter and 3,000,000 cubic feet capacity, at the Fulham station of the Imperial Gaslight Company, was made by Messrs. Westwood & Wright, of Dudley, the cast-iron work having been turned out by the Stavely Company.

Of the makers still nearer Birmingham, Messrs. Thomas Piggott & Sons, and Messrs. Hortons' gasholders are well known to probably nearly all the gas engineers in the kingdom. The last named firm have lately secured the contract for a large holder at the Western Gasworks, London, while Messrs. Piggotts are engaged upon one of 150 ft. diameter for Preston. Their largest holder was one, we believe, put up in Belfast, and 180 ft. in diameter.

The hydraulic punching and riveting machinery at Messrs. Piggotts' is extremely effective. In the rectangular plates any number of holes up to, we believe, 154, are punched at a single blow, and to the exact pitch. Originally the piston within a vertical steam cylinder of about 4 ft. diameter, and worked with 50 lbs. steam, had a rod or hydraulic plunger of 4 or 5 in. diameter, which was driven home with a force of perhaps 40 tons, equal to at least 2 tons per inch, forcing water equal to its own solid contents into an accumulator, from which it was let on, as required, to a pair of vertical 9 in. rams, placed over the bed of the punching machine. These drove down the punching head, carrying the punches, which were turned with shanks of a diameter equal to the intended pitch, and secured in rows, and with their shanks in contact, in grooves properly formed around the punching head. Each alternate punch was made ⅜ths inch longer than its neighbor on either side, so that although a single blow sent all the punches through the plate with a single report like that of a pistol, but one-half of the punches actually went through at once. The work thus done was exact, indeed perfection. Instead of the large steam cylinder, a pair of rotative pumping engines are now employed, the working pressure being 35 cwt. to 2 tons per square inch.

The hydraulic riveting is performed also by hydraulic pressure, at an average rate of thirty rivets per minute, the rate often rising, for a short time, to one per second.

Nothing would more nearly perfect the working of gasholder plates than the contrivance of a machine, if that be possible, for taking out the "buckles." This operation has now to be performed by hand, and it requires no small skill to effect it properly.—*Engineering.*

Cast-iron Tubes for water or gas are now made in England by turning off one end conically, and boring out the ends of the tubes to which it is to be fitted at the same angle, so that the end of one tube may be inserted into the other without the addition of the ordinary cement. The junction is effected very quickly, and the joint is perfectly tight. Pipes thirty-six inches in diameter have been perfectly joined in this way. Liverpool has about ninety miles of gas-pipe with this joint, and the leakage is said to be much less than in other cities.

Flexible Pipes are much used in Paris for rounding slight curves.

VAN NOSTRAND'S
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ENGINEERING MAGAZINE.

No. XII.—DECEMBER, 1869.—Vol. I.

THE LATE ORDNANCE COMMITTEE.

Written for Van Nostrand's Magazine.

By the two reports of the Select Committee on Ordnance, submitted to Congress July 17th, 1868 and Feb. 15th, 1869, the Ordnance Departments of the Army and Navy have been subjected to great reproach. In addition to charges seriously compromising the official integrity of certain officers, the whole service has been sweepingly condemned as incompetent and unqualified, persistently adherent to false practice and theory, and impervious to improvement. Its abolition is recommended, with the substitution of a board composed of officers and civilians. Knowing the causes which led to these investigations and reports, and having some knowledge of the persons who procured the appointment of the committee, and of their motives and antecedents, we have deemed it proper to lay before the public, so far as we may, a review of the whole matter. It need hardly be said that the subject is an important one, relating as it does to a most essential branch of the executive department of government, and the one charged with providing materials of national defense.

The report of July 17th, 1868, received considerable notice through various newspapers, and is already known to the public. It related, almost exclusively, to the action of the Chief of Ordnance in the purchase of rifle projectiles. The other report has received less public notice, although it was more sweeping in character and significant in language, being nothing less than a general arraignment and condemnation of the Ordnance Department in the strongest terms. We have deemed it proper to discuss the two reports separately, and analyze them in detail.

Fortunately, we are able to decline entering into any examination looking to the refutation of the charges contained in the first report, since this has been done most satisfactorily by the court of inquiry, summoned at the request of the officer whose record had been assailed. The charges made by the committee are not only met, in the finding of the court, by a flat denial, but are virtually pronounced to be utterly without foundation in facts, and the accused is directly complimented for his integrity and efficiency. The characters of the officers constituting the court will certainly place its finding beyond cavil on the ground of partiality or bias, or any ulterior motive, while the exhaustive investigation, extending over six months of almost uninterrupted session, and conducted by able and expert counsel on both sides, to whom was allotted the largest liberty in respect to the range of testimony, will be a good guarantee of completeness and accuracy.

In comparing the findings of the court and of the committee, we first note the fact that the evidence, upon which the charges rested, was substantially the same before both. The same witnesses were summoned for the prosecution before the court as appeared in the committee room, and reiterated their statements; the documentary evidence in the two examinations differed only in being much more complete at the second than at the first. It may then be fairly asked, how happens it that the two bodies arrived at diametrically opposite conclusions? If there had been evidence enough before the committee to procure such a strong condemnation as was actually delivered, the same evidence before the court ought to have, at least, qualified the acquittal. It will be borne in mind that the diversity of opinion was upon matters of simple fact and not of law. Had it been the former, it might readily be passed over as an ordinary difference of opinion upon a matter of principle, illustrating two ways of viewing the same thing, and both defensible; but in truth each body was called upon to report facts, and these are matters such as the law holds every hod-carrier and tinker capable of deciding. So cogent is this consideration that we are driven to the conclusion that, in one body or the other, the decision was determined, not by candid, impartial judgment upon fair evidence, but by a predetermination to convict or acquit without regard to the evidence. Unhappily a perusal of the two records allows no other interpretation. The issue was a simple one. Had the Chief of Ordnance been guilty of fraudulent transactions, and if so, what were they? No mere error of judgment, or difference of opinion, as between impartial men, could, under the circumstances, account for such contradictory decisions. On which side does the defect of justice lie?

A comparison of the constitution and functions of the two bodies may indicate where we may presumptively look for an explanation. The court was composed of three members and a Judge Advocate, viz: Gens. Thomas, Hancock, and Terry, and Judge Advocate Gen. Holt. The members of the court were sworn* to well and truly examine and inquire, according to the evidence, into the matter before them. The examination was by sworn testimony, in the presence of the accused, and was conducted by counsel on both sides. The rules of evidence were the same as in all other military courts, which conform to the practice of United States civil courts, as nearly as their peculiar constitution will permit.

The select committee was very differently constituted. It consisted of Messrs. Howard, Cameron, and Drake, of the Senate, and Messrs. Butler, Logan, and Schenck, of the House. Messrs. Butler and Logan were appointed a sub-committee to conduct the examination, the other members taking only a nominal part in it, and being seldom present in the committee room. Mr. Butler was almost the sole examiner. He was governed by no rules of evidence, and no precedents in the matter of practice, except the swearing of witnesses. No counsel was admitted, and no accused person being formally recognized, the really accused party was not present. It will be readily seen that a person so charged with the grave responsibility of furnishing Congress with information, which may be made the basis of intelligent legislation, and vested by that body with plenary power to subpœna witnesses from every corner of the land, without restriction as to whom he shall or shall not summon, or what testimony shall be admitted, and what refused, requires to be a person of surpassing ability, and most especially, to be above all prejudices. He is not merely an examiner, but a judge, whose decision is the only authoritative guide of Congress. We are averse to any invidious comparisons between persons of high distinction, but at the risk of making one, we are compelled to notice the complaints of Gen. Dyer's prosecutors that the finding of the court was "corrupt, arbitrary and illegal," arising out of the prejudices of the members, and a determination on their part to shield a brother officer, regardless of his crimes or the demands of justice. It happens that Gen. Butler has never been at any pains to conceal his sentiments towards the regular army, and doubtless many can recall his remarks at the last session when the army bill was before the House. We would like to propound the question, in view of these utterances, whether Gen. Dyer was not as liable to encounter adverse prejudices before the committee, as his prosecutors were before the court. We are quite content to leave it to the public to judge, whether the truth, in this particular case, was any more likely to suffer from the prejudices of Gens. Thomas, Hancock and Terry, than from those of Mr. Butler. Be that as it may, no one will venture to deny that the strictest impartiality was essential to the position Mr. Butler occupied. And yet, we do not hesitate to say, that he at once assumed the *rôle* of a prosecuting attorney, and conducted his examination in a thoroughly *ex parte* manner, while no opportunity was conceded to develop the other side by other testimony, and by cross-examination. Those who are familiar with legal processes may readily form some idea of what an astute lawyer like Mr. Butler

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* Article of War 93.

might be able to accomplish under such circumstances. But this was by no means the worst feature of the case: for after examining witnesses without interference, he was to bring in the verdict. To the most impartial man such a position would involve the gravest responsibility. How did Mr. Butler meet its obligations?

In a technical examination before a legislative committee, where the members are not thoroughly versed, or "expert," in the subject matter of inquiry, it is customary to employ the advice and assistance of expert examiners. Mr. Butler had occasion to avail himself of such assistance, selecting for the purpose Mr. Clifford Arrick of St. Clairsville, Ohio. Most certainly the selection was an astounding one. The important part taken by Mr. Arrick, in the course of the imbroglio, renders necessary such a sketch of him as we are able to give. Some time prior to the war he was an attorney, and subsequently, an examiner in the Patent Office. Here, having become familiar with the progress of invention in rifle projectiles, he at length became interested in an invention known as the Eureka projectile, patented by a Mr. Stafford of New York. By a piece of sharp practice Mr. Arrick obtained a patent for the same projectile in his own name*, and proceeded to urge its merits upon the Ordnance Bureau. Now, shorn of all verbiage, and reduced to its lowest terms, the report of July 17th, 1868, arraigns, tries, convicts and sentences Gen. Dyer, *because he declined to establish the Eureka projectile as the standard service rifle projectile, to the exclusion of all others as worthless*, the ascribed motive being pecuniary interest in a projectile of his own invention. We must digress a little. In the year 1857, Capt. Dyer invented a projectile, which may be considered as the type of a large and varied class. Subsequent developments have shown that he was not the first to apply, what may be termed the essential feature of that class, viz: an expansible cup of soft metal attached to the base of it. Still, he was *an* inventor, having at the time no knowledge of similar devices, and was the first to apply it, in this country, with any degree of success. The opening of the war and the success of rifled cannon abroad gave rise to numberless inventions, and modifications of inventions, of similar purpose, so that the year 1863 witnessed the establishment of several standard varieties, which were used with what were then considered very fair results. Though exhibiting wide differences in mechanical details, they all possessed one common feature, viz: a soft, expansible portion: compressible into the grooves of the gun by the force of discharge. This feature is a radical one in American ordnance, at present, and is sharply distinguished from the system more commonly adopted in Europe, which is exemplified by a projectile having grooves and lands fitting the bore of the gun. Confining ourselves to the American system, its extremes might be well represented by the Parrot and Hotchkiss. The numerous species, which may be said to lie between these extremes, were mostly developed as early as 1863 — all subsequent variations being hardly more than varieties. Some of them underwent modifications, mainly with a view to correct imperfections made apparent by actual service. On the whole, however, no new principle was brought to light. The Dyer projectile meantime had been superseded by the Parrot—its inventor, and, in truth, every other ordnance officer, being so wholly engrossed by administrative duties that no time was found to remedy certain deficiencies disclosed by practice. Up to the time of Gen. Dyer's accession to the command of the Ordnance Department, Mr. John Absterdam had presented two modifications of it, which did not make it in any respect superior and probably not equal to other standard projectiles. Yet it appears to have been the general conviction of the most expert ordnance officers, that a projectile with a soft metal cup at the base *ought* to be the best projectile* and, if properly constructed, would certainly answer the purpose more perfectly than any other. Its defects were felt to be matters of detail and not of principle. These opinions were amply justified by later experiments, when the Dyer projectiles had been subjected to important modifications.

In the latter part of 1863, Mr. Clifford Arrick first exhibited the Eureka projectile

*Singularly enough, Mr. Arrick had been employed as counsel by Stafford in an interference case, in which he succeeded in proving to the satisfaction of the commissioner, that, among several claimants, Stafford was the first inventor. Stafford subsequently assigned his patent to a company of which Mr. Arrick was the agent. Soon after, Mr. Arrick files an application for a patent for this identical invention in his own name, an interference is declared, and, by collusion, Stafford's assignees *fail to appear*! The patent therefore goes to Mr. Arrick by default. (Court of Inquiry Vol II. pp., 223).

* For field service at least.

to the ordnance bureau, and obtained an order for a preliminary trial, at which the action of the smaller calibers was pronounced "fair."* No action was taken by the bureau upon the report, and in the following May, a few more were tried at Washington Arsenal. The experimenting officer reported favorably upon them, with the exception, that the fuses failed to ignite, owing to the entire closure of the windage. After Gen. Dyer acceded to the command of the department, in September, 1864, an order was given for a further trial with 20-pounders having improved means for igniting the fuses. This trial elicited a highly commendatory report,† which warranted their trial on a more extended scale, in competition with standard projectiles;—the caliber selected being the 4.2 inch or 30-pounder. It is held to be a tolerably safe rule, among experts, that a projectile succeeding well in a larger gun will probably succeed well in a smaller, but not *vice-versa*—so that this trial was expected to furnish data only for 30-pounders and smaller projectiles. It was one of considerable importance, for it was expected to result in the restriction of the number of standard varieties. The competing patterns were the Hotchkiss ‡, Parrott, Schenkl, Eureka and Absterdam. Early in the trial the Absterdam, made in conformity with his second patent, and closely resembling the older Dyer projectile, failed most signally. But Mr. Absterdam had just obtained§ a third patent, and during the progress of the trial substituted the projectiles made in conformity with it for those which were giving such disastrous results. The trial terminated less decisively than was hoped, and failed to furnish means|| for a rigid comparison. The Eureka had shown itself to be a good projectile, but not uniformly so. On the other hand, the record of the new Absterdam was decidedly better, while the Hotchkiss, at the very last of the trial, gave, so far as tried, the best results of all;* in brief, the whole question was still in abeyance, except as regarded the Parrott† and Schenkl, which were less satisfactory than either of the others. At all events there was nothing whatever in the trial to warrant the enormous claim put forth by Mr. Arrick, that the Eureka had proved itself to be so decidedly superior to all others, that the Chief of Ordnance was bound to make it the standard service projectile, to the exclusion of all others as worthless.‡ That the court took that view of the case and scouted such a preposterous idea is clear, when it characterized the action of Gen. Dyer as merely an exercise of that discretion which unquestionably belongs to his position. Yet this was precisely Mr. Arrick's claim, as nearly as words can express it. He urged it in a large number of letters§ of portentous

* Made at West Point by Captain D. W. Flagler.

† The Washington trials were made by Lieutenant William Prince, and his reports, forwarded by Major Benton with a formal endorsement, were attributed by the committee to the latter officer.

‡ There were two Hotchkiss projectiles at this trial. The one first employed was the old one, so familiar to all our artillery officers; this is figured in the plate. The other one was quite new, differing from the old one *toto cœlo*. It was provided with an expanding cup at the base. It was not presented for trial until too late to obtain thorough results. By an oversight it was omitted from the plate.

§ The drawings in the plate are the second and third Absterdam patents; the one with the brass sabot being the third.

|| The following is an abstract of the results of the trial as tabulated:

Between February 11th and May 17th, the firings gave the following results: Parrott, 344 shots fired, with 55 bad shots; Hotchkiss (old pattern), 346 shots fired, with 31 bad shots; Absterdam, 232 shots fired, with 19 bad shots; Eureka, 200 shots fired, with 27 bad shots; Hotchkiss (new pattern), 52 shots fired and no bad shots. Ratio of bad shots: Parrott, .16; Hotchkiss (old), .089; Absterdam, .082; Eureka, .135; Hotchkiss (new), none. The Eureka had a very slight advantage over the others in initial velocity and range, in the general average, but was not uniform. The above *comparative* results were dated February 28th, 1865. The results with the new Hotchkiss were not received until June.

TABLE

Of comparative firings of 40 *shots of each variety at* 1,260 *yards, in February*, 1865.

	Total No. of shots.	No. of bad shots.	Percentage of bad shots.	Initial velocity; feet per second.	Direct hits out of 20 shots for range.	Ricochet hits.	Misses.	Vertical deviation, feet.	Horizontal deviation, feet.	Mean deviation, feet.
Parrott ...	40	10	.25	1,201	9	3	8	3.93	9.68	10.4
Hotchkiss..	40	5	.155	1,221	8	3	9	4.60	6.60	8.07
Absterdam	40	3	.075	1,221	6	8	6	2.33	6.23	6.65
Eureka ...	40	10	.25	1,247	10	5	5	3.90	6.70	7.75
Schenkl ..	40	37	.925	1,196						

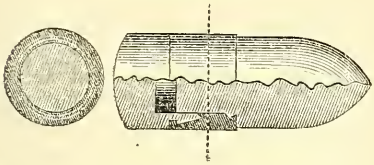
* Only 55 rounds were fired. The results were known only after the war closed.

† To show upon what slight structural differences the efficiency of a projectile may depend, it may be stated, that the only essential difference between the Parrott and the Absterdam is, that in the former the sabot, or base ring, is "flush" with the base of the shot, while in the latter it extends about .8 of an inch beyond it, forming a cup.

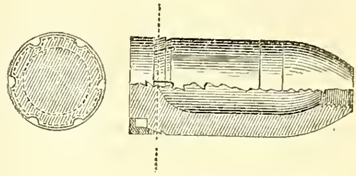
‡ Mr. Arrick made this claim very explicitly and repeatedly. See letters of Arrick to Dyer, dated Jan. 31st, Feb. 6th and 9th, 1866. Court of Inq., Vol. I, pp. 181–183; also id., pp. 196–206.

§ In the month of Oct., 1866, alone, he addressed nine long letters to the bureau on the subject.

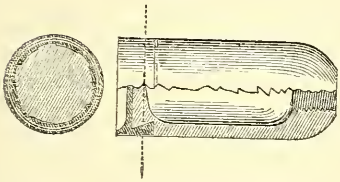
HOTCHKISS.



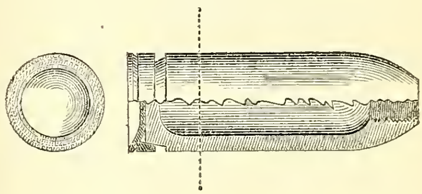
PARROTT.



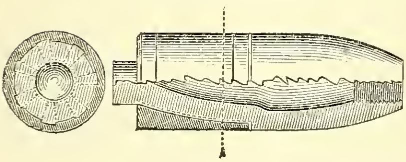
DYER.



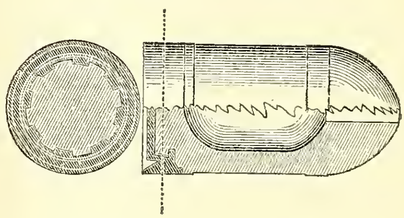
EUREKA.



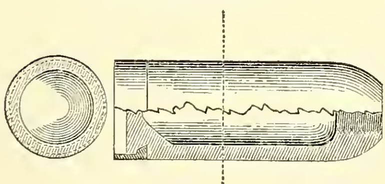
SCHENKL.



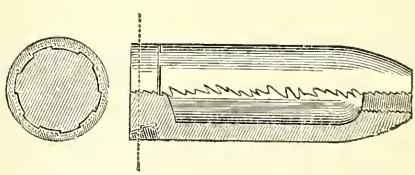
DYER
As modified by Mr. Taylor.



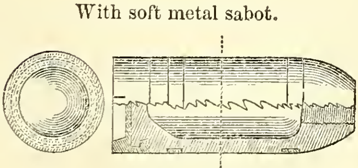
ABSTERDAM,
With brass sabot



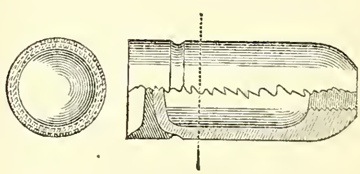
DANA.



ABSTERDAM,
With soft metal sabot.



SELLERS.



length, in which he lost sight of all reason and decorum. He spoke of the demands of the public service upon the Chief of Ordnance, which he was not at liberty to disregard, and insinuated that he was rejecting the only device worth having, by reason of his personal interest in a worthless contrivance which he was endeavoring to thrust upon the service under cover of a false name*, and through the agency of a man of straw. Of course such letters were eminently calculated to carry conviction with them, and to create a warm interest in the Eureka. After a large number of them had accummulated, Gen. Dyer requested Mr. Arrick to state specifically and exactly what he wanted, and received in reply a twenty paged letter,† amplifying the merits of the projectile, and culminating in seven propositions asserting its superiority over every other known device. He then desired the Chief of Ordnance to assent to, or deny them, or in case of doubt to appoint a commission to determine the question upon the records as they then stood. To this Gen. Dyer replied,‡ declining to be catechized; that the *comparative* merits of the Eureka projectile were understood by him, and that he had on hand over 5,000 of them, which would enable him to test their full merits whenever it was expedient to do so. In short, he refused to accept the alternatives of either rejecting altogether a good projectile, or of over-stating and overvaluing its merits.

No person of ordinary intelligence will have any difficulty in correctly appreciating the merits of this controversy. Mr. Arrick claimed to have an invention which ought to supersede every other for similar objects. But was there ever a patentee who was not ready and eager to claim the same thing? For five years or more the Ordnance Office was daily thronged with sanguine inventors, and owners of inventions, making the same claim, each strenuously asserting that he had anticipated for many years to come all possible improvement in a particular direction, and thinking that the Chief of Ordnance, and all his subordinates, were the embodiments of stupidity, because they thought differently. Each inventor seemed to entertain the idea that the Government was bound to accept off hand, or, at least, to try his own particular contrivance. Let some statistician calculate the expense of satisfying, either by acceptance or trial, the expectations of these gentlemen, and he will be edified. Are men of business in the habit of purchasing new inventions without knowing their merits? Are they in the habit of testing them for the sole emolument of the inventors? In a word, is not the usual and proper course, in such matters, to purchase them if you think they will pay, and to let them alone if you don't? Now, what earthly reason is there why the Government, through its officials, should throw away this prudent and universal practice? These officers are required to judge of the exigencies of their respective departments, precisely as the proprietors of private establishments judge of theirs, and to manage them in the interest of the Government, and not of inventors and contractors. Mr. Arrick demanded, in no very gentle terms, that his projectile be accepted, against the judgment of the department, and upon no decisive record, though he afterwards proposed to subject it to the form of a trial§ which would cost $20,000. As the department had on hand an enormous supply of projectiles, which, in its opinion, were as good as, not to say better than, the Eureka was likely to prove, it was deemed inexpedient to spend a large amount of public money in settling a question of no practical importance at that juncture. Even admitting, for the sake of argument, that the Eureka may prove to be somewhat superior to any other ever urged upon the bureau, is the Government, at the close of a gigantic war, and weighed down with debt, to incur further expense in demonstrating the value of an article it does not want?

After four years of solicitation; after he had become intolerable to the bureau and everybody connected with it, Mr. Arrick came to the safe conclusion that he had spent much time and money to no purpose. We believe his friends will not assert that, in his wonderful persistence, he was so disinterested as to work from purely patriotic

* Letters of Arrick to Dyer, Feb. 9th, 1866, Court of Inq. I, 182, and id., Oct. 16th, p. 198. Mr. Arrick claimed that the Absterdam was but another name for the Dyer projectile, and that Gen. Dyer was receiving royalty on the purchases, and using Absterdam to conceal the transaction. This is the gist of some of the accusations in the report of the committee.

† Letter of Arrick, Oct. 25th, 1866, Court of Inq., Vol. I, p. 201.

‡ Letter of Gen. Dyer to Arrick, Oct. 27th, 1866. Id., p. 203.

§ Arrick to Dyer, July 9th, 1867. Id., p. 222.

motives, nor are we aware that he claims any motive but the pursuit of emolument; and when we find him thoroughly committed to the serious undertaking of the overthrow of the Ordnance Department, we see no escape from the conclusion that his incentives were money, and, perhaps, revenge. We are by no means left to conjecture alone on this point. He expressed himself ready to relent if his claims were conceded by the bureau*, but in the other event he was resolved to spare no effort to demolish it. It seems that he did not lack powerful co-operation. We are not aware by what means his determination was made known to the Select Committee, nor is it material. His own account of the affair is, that he knew the committee wanted him, and were about to send for him, and he anticipated their summons†. And so Mr. Arrick became the expert examiner and adviser of the committee in the investigation of Gen. Dyer's action in the purchase of rifle projectiles.

Were it necessary we would detail some of the operations by which testimony before the committee was perverted; how Mr. Absterdam was made to testify that he had no patents, when he had them in his pocket; how indignant the old gentleman got when he told the court that his evidence, as it appeared in the record of the committee, was a mutilation, a forgery, and he repudiated it‡; how the Absterdam projectile, of the third patent, which had been purchased so extensively, was shown to be "absolutely worthless" by quoting the record of projectiles made under the second patent§—a different affair altogether; how a poor woman was made to testify‖ that Gen. Dyer had claimed a royalty on these projectiles in the Ordnance office, and in the presence of several individuals; a statement which Mr. Field, by a few minutes cross-examination, showed to be an ambiguous perversion of a remark which did that officer no little honor. But we pass them by, for they are all rendered ineffectual by the finding of the court.

A fitting termination to this marvelous investigation was the preparation of the report. After giving over the body of the Chief of Ordnance to his adversaries, to wreak such vengeance upon it as they saw fit, and to toss and gore it in the committee-room, it might be thought proper that the drawing and quartering of the remains should have been done by the representatives of the law. But the committee thought otherwise.

Mr. Arrick states. in his testimony before the court, that, by a general understanding with the committee, he wrote the report, presented it to Mr. Butler, who read it over, reduced it by striking out certain passages, and re-committed it to Arrick, who made the corrections and again submitted it to Mr. Butler, by whom it was accepted and presented to the full committee, who in turn delivered it to Congress as the report, in part, of the Select Committee on Ordnance. *The whole text was written by Mr. Arrick, verbatim, as it now appears, with the exception of the last three lines.** As nearly as we can figure it, this report cost the country in the neighborhood of $200,000, and the net result of the expenditure is, that Congress and the country have been enlightened as to Mr. Arrick's opinion of the Chief of Ordnance! Why! Mr. Arrick was boiling over to give it to them for nothing but the asking!

The next subject, covered by the report of Feb. 15th, 1869, was that of heavy guns. Mr. Butler being occupied with the impeachment case, took no active part in this—his place being, in a measure, supplied by Mr. Howard. This subject being far more difficult in point of scientific principles involved, the same necessity existed for a resort to expert assistance. That an eminently qualified person should be selected was a matter of the first importance. To convey to Congress information which would enable that body to form a correct, comprehensive, and concise opinion of the state of modern ordnance in general, and of American ordnance in particular, is a task from which the most accomplished expert in the land might well shrink.

In England, during the last fifteen years, not less than £25,000,000 sterling have been expended by Government upon experimental artillery. Enormous sums, of which we have no record before us, have been expended in a similar way by the continental nations of Europe. The most accomplished engineers, army and navy officers, iron masters and mechanics, have added their severest

* Arrick to Charles Knapp, Feb. 22d and Mar. 7th, 1868. Id., Vol. II, p. 341.
† Arrick's testimony, Id., p.
‡ Compare Absterdam's testimony before the committee with that before the court, Vol. I, pp. 28-29.
§ Cross-examination of Clifford Arrick, Court of Inq , Vol. II, pp. 228-229.
‖ Testimony of Mrs. E. Dixon, Id., pp. 362-371.

* This is Mr. Arrick's own version of the affair, Court of Inq., Vol. II, p.

labors, and most strenuous efforts of intellect and capital, to aid in the solution of the ordnance problem. In England, France and Germany, where new processes and new machinery for the manipulation of iron and steel have succeeded each other with marvelous rapidity, and upon a constantly increasing scale of power, the utmost that has been looked forward to, is some process which will render practicable and reliable the construction of the enormous guns demanded by modern warfare. In America, owing to the greater scarcity and cost of capital, and the backward condition of machinery for manipulating large masses of metal, no such immense establishments as those of Sheffield, Birmingham and Essen, are in existence. The attention of ordnance officers and civilians has therefore been confined to such materials as the workshops of the country are capable of manipulating, and that material, so far as the largest guns are concerned, is cast-iron. In this limited field have been employed the talents and energy of our most practical and learned constructors. The question of ordnance has long involved the labor of the highest mechanical genius, the most ponderous machinery, the largest accumulations of private capital, and the most lavish expenditure of public funds of any scientific question before the civilized world. Whom, then, did the honorable chairman of the Select Committee on Ordnance select, as his representative, to elucidate and expound this lofty subject to the national legislature? We have no hesitation in asserting that, out of the thirty-five millions of people in these States, Mr. Howard selected the man possessing the most obnoxious disqualifications, and the greatest number of them.

We pause here to apologize to the readers of the ECLECTIC. We are adequately impressed with a sense of the dignity and impersonality which should characterize all professional discussions. We also asseverate a profound respect for the wisdom, patriotism, and official dignity of our national legislature, which we desire to extend to all its constituent parts and members. But we find ourselves embarked in a serious discussion, which brings us face to face with a most anomalous state of affairs. On the one hand, we find a man making the loftiest kind of pretensions to professional science, and yet is at the farthest remove from it. These pretensions are not made quietly, modestly, and deferentially, in the ordinary range of private or literary discussion, but coarsely, blatantly, and abusively, before a high inquest of national importance. On the other hand, we find a congressional committee accepting implicitly these false pretensions, and using their high powers to push their consequences to the uttermost. We have a general interest in this matter, as a lover of truth and a citizen of the republic, and we have a special interest in it as a member of that small but select body, whose professional reputation is immediately assailed. What is our duty in the premises? Is there any alternative but to tell the whole truth, regardless alike of personalities, or of the character of any committee whom our honorable Congress may see fit to designate?

The person we refer to is Mr. Norman Wiard. He, too, was a disappointed aspirant for wealth through dealings with the Ordnance Department. Like Mr. Arrick, he had an invention to offer, the adoption of which he had urged through long and weary years, with an energy and importunity such as is known only to that desperate class who throng the departments and infest the portals of the capitol. Many of them are men of capacity, and certainly some of them mean to be honest. Some, too, have personal qualities, which, if exercised in a moderate but honest capacity, and controlled by moderate and rational ambition, would make them invaluable members of the community. But they are men of desperate need, and, at the same time, bitten by an inordinate desire to accumulate wealth out of public patronage. Their ravening hunger obliterates all perception of public interest and morality. Now, if eight years of untiring solicitation for the Government acceptance of chimerical schemes, the receipt of $136,809 in Treasury drafts and certificates, for which the Government cannot, and never could, show $25,000 worth* of effects; the repeated memoralizing of Congress† against zealous and upright officers, and in favor of a corrupt scheme of private emolument at the public expense—if hob-a-nobbing with

* All of the ordnance material furnished by Mr. Wiard to the army and navy, excepting such as was made in conformity with regulation patterns, was found to be unserviceable in the field. The army commanders who had requested a supply of his semi-steel guns, were the first to request their withdrawal.

† There are several memorials of Mr. Wiard to Congress, the most infamous being that which was referred to the Committee on the Conduct of the War, in 1865.

those Congressmen who are not particular about the company they keep, and persuading them to recommend that Congress appropriate $125,000 for a claim* which is fraudulent in its very essence—if instigating and procuring the appointment of a congressional committee† to recommend the dismissal of a select corps of zealous public servants, for no other earthly reason than because they refused to lend themselves to these iniquitous schemes; if these things entitle a man to a high position in the category of the "third house," as we have described it, then Mr. Norman Wiard belongs there. We wish it distinctly understood that we make no charges which we cannot prove under the seal of official record, and we shall in due time give the proper references.

We shall first proceed to characterize the peculiar invention he has sought to establish. Mr. Wiard was occupied, in the year 1862, in the fabrication of some semi-steel 50-pounders for the Navy Department. When subjected to a very moderate test, these guns burst with surprising facility. In speculating upon the reason why a metal, having such high tensile strength, should exhibit an endurance inferior to cast-iron, he came to the conclusion (by what logical process he does not inform us) that some agency was concerned in the destructive effects of firing, other than the mere expansive force of powder. It at length appeared to him that the intense heat of the ignited powder, together with that produced by the friction of the shot against the surface of the bore, would occasion a difference of temperature, as between the interior and exterior, tending to compress the former and extend the latter. Guns fired rapidly, would, in this way, be subjected to a constantly increasing tension, which, added to the force of the discharge, would ultimately produce rupture. Satisfied that he had solved the problem, and that his solution covered every case of rupture, he applied himself to the devising of a gun which would compensate this difficulty. In 1864, after much solicitation, he procured from the Navy Department a contract for the construction of two 15-in. guns upon his plan, designed to obviate the supposed effects of heat. The first gun was condemned in the pit; the second was finished and broke into many pieces at the first discharge. The department did not deem it advisable to expend any more money upon an experiment of this character, and although Mr. Wiard's importunities have been very great, they have been invariably declined.

A discussion of the hypothesis he has advanced, we must decline entering into, further than to state a few facts. That a gun is heated by firing, that the heat so produced is greater in the interior of the gun than at the exterior, and that the difference of temperature may, in most cases, produce to a small extent the tensions Mr. Wiard assumes, are doubtless true. But the question is one of degree. Mr. Wiard assumes that these tensions are something enormous—every gun founder and constructor of experience knows them to be so small as to be practically immaterial. But whether they be great or little, his proposed plan for obviating them will appeal only to "the risibles" of the true mechanic, and if it has never been duly characterized by competent authority, it is because such authority has deemed it too bizarre and whimsical to dignify it with notice. There are two ways of substantiating a physical hypothesis—one analytically, by mathematical demonstration; the other empirically, by experiment, and a complete demonstration should properly involve both. Mr. Wiard has given no analysis of the effect of heat upon the metal of a gun, and his hypothesis, therefore, rests upon no theoretical basis. We cannot recognize the statements he has made concerning the effects of heat, or sudden cooling, upon various masses of metal as having any bearing whatever upon the thing to be proved. When he submits an analysis showing, within a reasonable approximation, the amount of heat communicated to the gun, the rate at which it is conducted through the mass, the degrees of tension produced, and the relations of these forces to the ultimate strength and elasticity of the iron, intelligent mechanics will be happy to give it such careful and respectful consideration as it merits. At present they have no tangible theory to work upon, but only a few incoherent assertions on his own authority, which is opposed to that of all constructors known to the public. As for facts, they are all against the hypothesis. No gun ever burst under circumstances which could prop-

* Fortieth Congress, Third Session, House Report No. 6.

† There is no room for doubt at whose instigation the committee was appointed. The numerous letters of Arrick, Wiard, and Horatio Ames (see Vol. II, Court of Inq.), contain abundant evidence that they procured it, and were able to control it.

erly warrant the assumption that it was due to any cause, other than the expansive force of gunpowder. But numerous experiments* have been made with a view to test this question. Guns burst indifferently, whether fired rapidly or slowly, or, as in the case of some of Mr. Wiard's, at the first discharge, in which the assertion of such a cause is a contradiction of terms.

Mr. Arrick is a true expert, and the contrivance he urged upon the bureau had great merits; but Mr. Wiard is a charlatan, and his gun a mere monstrosity. In his evidence before the committee he undertakes to expound the nature of the mechanical forces involved in the action of gunpowder. Whoever will take the pains to read that exposition will, if he be versed in the doctrines of mechanical science, at once recognize the fact that the whole testimony is an imposture—a pretense—an aping of knowledge, which he does not possess, and never can possess, until he has at least gone through a course of study and instruction, such as is required of every school-boy who becomes a candidate for a bachelor's or professional degree. It is a bold attempt to persuade the committee that the laws of force, as taught by every mathematician since the days of Galileo, are foolish misconceptions, and that the only true wisdom the world has ever seen, has found its incarnation in Mr. Norman Wiard. The notions of this man are no ordinary errors. They are such as can exist only in the absence of a capacity to understand the fundamental principles of mechanics, as taught in every school book, and elaborated in every treatise, from the theory of falling bodies to the *Mechanique Céleste* of Laplace. Either the whole world beside is utterly wrong, or else Mr. Wiard is—not only in special deductions, but in the simplest principles, which every unbreeched school-boy is bound to know. Really, matters have come to a strange pass, when the Ordnance Department is to be compelled to defend, not merely its system of ordnance, but the first principles of Weissbach, Bartlett, and Moseley, against the assaults of an imposter. We should like to see Mr. Wiard, or anybody else, take his assumptions about the "projectile force" of powder,* and apply them to the fundamental equation $Q = \int P\,ds$, and to see where he will come out.

Whoever likes to contrast the insolence of ignorance with the modesty of true knowledge may turn to the testimony of Gen. Rodman. Here is an officer whose reputation as a man of high scientific attainment is world wide, and whose practical experience in gun founding is as extensive as that of any living man. His statement of the merits of the system which bears his name is qualified by a full acknowledgment of the limits of its advantages, and an humble sense of the difficulties which beset the whole subject, arising partly from a want of experimental knowledge, and partly from the unsuitable nature of the materials we have to deal with. Mr. Wiard, a man innocent of learning, who never made a reliable gun in his life, lays claim to complete knowledge, where all other men are silent, solves by a dictum every moot question, and charges other men with ignorance, stupidity and dishonesty.

But we have more serious charges to bring against Mr. Wiard than mere ignorance. In

* After the action of Fort Fisher, several 100-pdr. Parrotts were fired over 1,000 rounds each, one of the objects of the trial being to determine whether rapid firing exerted any appreciable effect. (Of course it is possible to fire more rapidly experimentally than in action, where time is consumed in sighting.) Nothing was developed by the experiment. It has become usual to conduct a part of the extreme proof of guns with the same view. No appreciable effect has ever been observed to result from rapid, as distinguished from slow firing. Out of the enormous quantity of experimental firings which have been made, it is a sheer impossibility that any such cause could escape detection if it had any real existence.

* Mr. Wiard seems to entertain the idea that the velocity of the projectile is the result of *two* forces, viz: the static pressure of the ignited powder, and the *vis viva* with which the powder is projected against the projectile. After elaborating this view with considerable minuteness, he then proceeds as follows:

"Q. What is the difference between the projectile force and the pressure of the powder, and has one a fixed and continuous relation to the other?

"A. The projectile force of the powder is the force equal to that which would be developed or exhibited in stopping the projectile. The pressure is that force which gives it motion in the gun, and it can be seen that if such a force as that acting upon the projectile should act against the surface of the bore in the gun, no material could be found from which guns could be made, which would not either enlarge the bore, or burst as a gun, unless it were from material which, if formed into a plate, and fixed upon the side of a ship as armor, would resist the impact of a shot from a gun without any indentation whatever. When a wrought iron shot is fired from a gun at a plate, which it does not penetrate to any considerable depth, the shot is flattened by the impact. If the pressure of the powder were not less than the projectile force, the shot would be invariably flattened to the same extent in the gun, which, however, is not the case."

We leave the educated mechanic to groan in spirit over this.

his testimony* he refers to a report of the Chief of Ordnance, which speaks of certain "ignorant, or designing persons" who have "hindered the furnishing by the Department of 1,915 large guns." Mr. Wiard says, "I hope you will credit me with having prevented the perpetration of a gigantic swindle thereby." We are much obliged to him for the word. We shall probably agree as to its meaning and differ only as to who is the swindler.

In October, 1861, he received from the Navy Department an order to finish a number of 7½ in. guns†, the blocks being furnished him. Having no means of his own he sub-let the work to one, William A. Miller, of New York. When nearly completed, an inspection was held, and it was reported that $5,270.00 had been earned, which amount was paid to Norman Wiard. Mr. Miller never saw a dollar of this money and held the guns as a lien. Their delivery was demanded of Mr. Wiard by the Navy Department, but he failed to respond and ultimately the guns were forcibly removed by the Commandant of the Brooklyn Navy Yard.

In August, 1861, Mr. Wiard received an informal contract to furnish the Navy Department with a number of semi-steel 50-pounders.‡ They were to be deliverd in lots of five, and upon the notification of the acceptance of each lot after inspection, an order for a new lot was to issue. The first six guns submitted for inspection failed§ most signally. Three of them burst by firing less than eleven rounds with five pounds of powder, and a fourth—the trial gun—had been disabled after some 350 charges. One of these guns, after bursting, was found to contain a false bottom, which had been inserted to hide an error of dimensions. In the investigation which followed, Mr. Wiard asserted his ignorance of the fraud and charged it upon various manufacturers and artizans who had immediate charge of the work. One of these persons acknowledged the sole responsibility and in his defense made some very significant disclosures. His statements were sustained by the affidavits of four men*, who were in no wise implicated in the fraud, and whose testimony is unimpeachable. It seems that the practice of doctoring sick guns was a most extensive one at the establishment where Mr. Wiard's 50-pounders were made, and that he himself inaugurated the system. Flaws were hammered up, seams brazed and holes plugged with screws.† Guns which had been rejected were artfully tinkered‡ and restored to their vacant places—all by Mr. Wiard's own orders in almost every case specifically, and against the repeated protests of his manufacturers.

Of these 50-pounders the Department accepted only one—the first and trial gun, which was paid for. Mr. Wiard made ten, of which four were never brought to trial. Of the other six, two were fired ten times without injury and landed by Mr. Wiard at the Navy Yard. They were never received by the Government, and yet Mr. Wiard presented a bill for them,§ amounting to $9,671.30. As the Department declined to pay for them, he proposed that the subject be submitted to a commission, promising to abide fully by its decision. The commission was appointed conformably to his request, gave the matter a full hearing, and reported adversely to his claim. We shall soon see how he kept his promise.

In April, 1863, Mr. Wiard entered into a formal contract‖ with the Navy Department to cast a 15-in. trial gun upon his peculiar plan, designed to obviate the effects of heat. When ready for trial he was to receive one-half the full price, which was to be 25 cents per pound, the balance to be paid when the trial was completed. In case of failure he was to be allowed to make a second gun under the same conditions, which, if successful, was to be considered as the trial gun. As we have already stated, the first gun was

* Testimony of Norman Wiard before committee. Report of February 15, 1869.

† See letter of Sec. of Navy to Senate 41st Congress, 1st Session, Senate Ex. Doc. No. 11, March 31st, 1869. This document is a compilation of official correspondence between Norman Wiard and officers of the Navy Department submitted without comment. The statement we give we vouch for as being a correct epitome of the statements therein contained.

‡ The whole history of these 50-pounders will be found in the document just referred to.

§ One was fired 350 times when it showed an excessive enlargement of the vent; one burst at the ninth fire; one at the tenth; one stripped a land at the first fire and exhibited at the tenth fire a crack about four feet long.

* See affidavits of William L. Miller, George P. Gernster, J. T. Plass, and Isaac P. Tice. Id. pp. 52–58.

† Id.

‡ Every iron maker knows well enough that of all forms of iron the most treacherous and worthless is semi-steel as it is called. It is in effect a wretched half kneaded and half cooked variety of wrought iron utterly unsuitable for any purpose known to the arts.

§ Id.

‖ Id. The contract in full is published in the document referred to.

an imperfect casting; the second burst at the first fire, and terminated the contract. Mr. Wiard was paid $5,160.00 for the first gun,* and $4,295.00 for the second. In acknowledging the receipt he signed an explicit statement† that the acceptance was a final settlement of all claims against the Navy Department.

On the 13th of January, 1869, Mr. Schenck, in behalf of the select committee, reported to the House‡ a bill appropriating to Mr. Wiard the sum of $42,180.00 for nine semi-steel 50-pounders, and $83,668.49 for various expenditures attending the preparations for, and the construction of, two 15-in. guns, making a total of $125,848.49. Through the personal representations of Mr. Schenck this bill was passed by the House, and went to the Senate, where Mr. Howard, the chairman of the select committee, urged its passage. Fortunately, Mr. Grimes of the Naval committee happened to be aware of the true nature of the scheme and at his request the bill was defeated.

We have been permitted to see the original of the following letter, to the genuineness of which we can certify. We withhold the name of the firm to which it is addressed out of deference to their desire to avoid a publicity nowise agreeable to them. At the same time they are ready to make any acknowledgments which public interest may require.

May's Building, Room 3, cor. 7th and E, Washington, 21st June, 1869.

Gentlemen: It affords me gratification to be able to forward to you by mail a copy of the last report of the Joint Committee on Ordnance on the subject of heavy ordnance.

I do not know how far you have made yourselves acquainted personally with the theories I have advanced for the past eight years, in relation to the "ordnance problem." I therefore, also forward to you a copy of a communication I made to the committee on the conduct of the war, early in 1865, believing that you cannot fail to appreciate the renewed consequence, which attaches to the subject, by the determination of the fact, that 1,915 large guns are required for the fortifications, according to the report of the Board of Ordnance Artillery and Engineer officers, approved 20th of February, 1867, concluded, as shown on page 171 of the report of the Ordnance Committee; and in view of the facts, that the Rodman system is now condemned by the appropriating branch of the Government, the Parrott system being no longer in competition, and the Dahlgren gun obsolete, on account of the changes in the means of defense adopted in all countries, I flatter myself that my views on this subject are in the ascendant.

While the Rodman patents were operative (they expired last year), the money interest, with which they were sustained, could overwhelm me. Now feeling confident that I possess the only practical manner of making large guns, and that it is secured to me unassailably by patents, issued or to be issued, I hold that I have achieved a monopoly of the gun business of the future, according to law, and if any of those parties, who have heretofore opposed me in the interests of the Rodman patents—now that those patents have expired—should continue their attentions in a revengeful spirit, I have only to invoke the majesty of the law and they will be removed. As evidence of this, I forward a third publication, to which I ask your attention.

And now the real object of this letter: I am about to enter upon the gun business, either by building a foundry in Washington, or by making an arrangement with some of the already established foundries, for the production of guns upon my new system, and I desire to know if this fact interests you in any degree. I have no idea that I could impress you favorably with my plans, otherwise than at a personal interview, which I should be glad to promote, if I should learn that you were desirous of participating in it—not otherwise.

If you have any doubt of my skill, persistence, or integrity, or security—and I know there have been some reasons for doubt spread abroad—I desire to refer to Mr. Sam. Sinclair, of New York City, a gentleman who has known me well for many years. Mr. Sinclair is publisher* of the Tribune.

Hoping you will respond to this,

I am, Gentlemen,

Yours &c.

Norman Wiard.

It is certainly a most unpleasant task to us, dealing in such personalities; but we have no alternative. A great congressional committee has paraded Guy Fawkes before Congress and the country, and we are bound to hurl missiles at the effigy—or to borrow a stronger phrase from Macaulay, "the attempt to enshrine this carrion has compelled us to gibbet it."

The reader of the Eclectic will now be able to form some conception of the mockery of that investigation. It was an additional refinement of injustice, over and above that, in which Mr. Arrick figured so extensively. In that one Mr. Butler kept up the outward form of an investigating committee; but in this Mr. Wiard filled the chair, prepared the questions, catechized Admiral Dahlgren, Gen. Rodman, Col. Laidley and finally himself. The situation of the two former officers forcibly recalls the description in the Pilgrim's Progress of the trial of poor Faith-

* Id.

† Reading as follows: "I hereby accept the above as a final settlement of all claims against the Navy Department."

‡ Fortieth Congress, 3d Session House Report, No. 6.

* Which will account for the periodic onslaughts of that journal upon the Ordnance Department.

ful before Lord Hategood and the jury of personified vices at Vanity Fair.

"JUDGE.—Thou runagate, heretic, and traitor hast thou heard what these honest gentlemen have witnessed against thee ?

"FAITHFUL.—May I speak a few words in my own defense ?

"JUDGE. — Sirrah sirrah ! thou deservest to live no longer but to be slain immediately upon the place; yet that all men may see our gentleness to thee, let us hear what thou, vile runagate, hast to say."

We are not prepared to assert positively that Mr. Wiard drafted the report, because we have no direct proof; but judging from internal evidence we entertain little doubt of it. That, however, is scarcely material. The report is all he could have wished it to be. It condemns every system of ordnance except his—denounces in most opprobrious terms the Ordnance Department and its system of artillary, and recommends its abolition, and the substitution of a mixed board of officers and civilians. We do not see what he could have desired to add, unless it be the appropriation of a large sum of money for his own benefit, which the committee sought to effect in a more efficacious way by a separate report.

We have entered more deeply into the personal details of this business than was agreeable to us, because we have felt that in exposing the characters of these men we are enlightening the mechanics and engineers of the country as to the animus of the committee. In their individual capacity we are desirous to avoid all contact with Messrs. Arrick and Wiard: they are formidable only through their connexion with the committee. Since the committee placed its high authority unreservedly into the hands of these men, with no restriction as to its use, and making it merely a cover for whatever they chose to say, we are bound to show the characters of the men who were the recipients of this confidence. The real committee was Messrs. Arrick and Wiard, and the lawful committee stepped in only to give the investigations of these two men the weight and sanctity of its official character.

We feel that it is not for us to assault formally the characters of Senators and Representatives further than to state facts. The inferences we shall leave to the readers. Here are two reports—the first, written by Mr. Arrick, vituperating the Chief of Ordnance for no alleged and no conceivable reason except that he declined to make the Eureka the standard rifle projectile "to the exclusion of every other known device as worse than worthless;"—the other, written (in all human probability) by Mr. Wiard, vilifying the whole Ordnance Department, because it equally rejects his grotesque cannon. And yet, after the form of an investigation, the committee adopts them in all their grossness and in all their *ex parte* character—recognizes their serious consequences, as involving an entire change of the management of the ordnance service, and a substitution of the material of these adventurers for that already in vogue. If it be said that the committee may have been deceived, and led to espouse the cause of these men through artful misrepresentations, then the reader may ask himself, what right had they to be deceived, when they were so explicitly charged by Congress to ascertain facts and report them ? What right had they to base an opinion of a considerable and honorable body of officers, upon the sole representations of their bitterest enemies ?

We cannot close without adverting to the recommendation that the Ordnance Corps be abolished. That is a matter for Congress to decide, and any decision which may be made by that body, after a full and impartial investigation, and when it is in a position to comprehend and appreciate the subject in all its bearings, will be most cheerfully acquiesced in by the officers affected by it. Probably no corps of public officials could so well bear to be thrown upon their own resources, or is better qualified to meet the exigencies of an entire and forcible change of profession. But an honorable discharge from the service is one thing, and being kicked out for refusing to facilitate the various schemes of plunder set on foot by the Arricks and Wiards of the Washington lobby is quite another. The charges of incompetency, of the "lack of the incentive to exertion and improvement, which stimulates men not in the Government employ," the "attchment to routine," "jealousy of innovation and new ideas," "discouraging the inventive talent of the country," and the "improper and oppressive treatment of persons, who have sought to call their attention to what were supposed to be vital principles of the art" etc., etc. will pass for what they are worth. They mean simply that the Department could not appreciate the "new ideas," the "inventive talent," the "vital principles of the art," involved in Mr. Wiard's "Munchausen Artillery."

That a strong pressure will be brought to bear upon Congress, the coming winter, to abolish the Ordnance Department, or merge it into the artillery, we readily foresee. We are not disposed to make any plea for its continuance, except on the ground of public expediency. It is certain that there must be a class of officials, either military or civil, whose special functions must be the administration of ordnance duties and the provision of ordnance material. It is for Congress to judge whether these functions will be best fulfilled by civilians, or by the military; by officers specially educated for it and of protracted experience, or by officers without experience. The term ordnance is suggestive of guns; but in reality involves a whole world of executive details. It comprises manufactures, a knowledge of business, of fabrics, and of construction, far more extended than any mere trade or class of trades. Its officers are *entrepreneurs* between civilian supply and military consumption, and to be efficient and economical—to insure to the Government an equality in bargains and protection against fraud, to regulate supply by the demands of the service and to systematize the means and methods of supply, must be men who are thoroughly acquainted with the mechanic arts, the trades, the details of ordinary business, and the routine of military service. These duties must be discharged by a body of specially qualified men or the abolition of the present Ordnance Department will merely render necessary the construction of another. It would be a change of persons and not of system.

We are tempted to make one remark which we hope some Congressman will see and make a note of. If the Ordnance Department is worth anything, it ought to have the confidence of both Congress and the people. But if its recommendations are to be disregarded, its aims and purposes defeated, and its chief and his subordinates arraigned and thrown upon their defense every time an over sanguine inventor or unprincipled adventurer chooses to impeach them, then it is high time to abolish it. Like every other subordinate branch it derives its efficiency and capacity for usefulness from the confidence of the Government.

A comparison between the merits of the American Ordnance and foreign may be made briefly. As yet American Ordnance contains no *established* system but the Rodman Army, and the Dahlgren Navy, guns. The large calibers are all smooth bores. The few rifles, which have been subjected to experiment, have not given such results as to warrant their adoption;—partly because the trials, which have been made, have not accurately tested the proposed system, and partly because the trials have been exceedingly meagre*: nothing is predicted for them, but much is hoped. As for the large smooth bores, they have hitherto sustained every test, and no one of them, in the army at least, has ever burst, except after a good and sufficient measure of endurance. For the Navy we are unable to speak. During the war the Parrott rifles were extensively used. A considerable number of these burst, although the general performance of them —all things considered —was wonderfully good. These guns may be considered either good or bad, according to the standard by which they are judged. If a perfect gun be demanded, a gun which will never burst, no matter what the caliber, or the charge of powder used, then the Parrot gun was a failure. But if there be demanded as good a gun as could be built at a practicable cost, and with reasonable celerity, and which would endure, in nineteen cases out of twenty, a liberal amount of service, the Parrott gun was eminently a success. During the late war there was no large rifle in existence to be compared with it. If the carping critic chooses to point to its failures, instead of its good service, the reply is easy. It was by an immense interval the best gun of its class at that time, and it remains to be seen how much improvement has been made, since 1865, in the construction of heavy rifled artillery. That better guns have been made in England and Prussia is admitted; but whether they can be furnished in quantity, of a guaranteed endurance, and at a practicable cost is not yet fully decided. The Parrott† rifle has been adopted only provisionally until a better system can be established.

Turning to European Ordnance, we find everything in a transition state. The colossal works of Krupp, at Essen, have produced enormous rifles, which have been fired with heavy charges about 400 times, and more recently the Fraser gun has given re-

* Of the heavy Rodman rifles only three have been put to proof. One 12-in. rifle was fired 470 times before bursting; one 8-in. rifle fired 1,080 times and one 8-in. rifle 80 times.

† The country owes much to Mr. Parrott. His services have proved far more valuable than those for which Sir W. Armstrong was knighted.

sults, which are certainly promising, having sustained over a thousand fires with charges of great strength. But no European Government entertains, as yet, the least notion of adopting any one of the many systems undergoing tests, until these tests shall have accumulated so as to place the endurance of the guns beyond the possibility of a doubt. Any other course would involve a most unwarrantable risk. The enormous cost of such guns would render their definitive adoption a matter of as much solicitude as a cabinet crisis or a *coup d'état.* In brief it is safe to say that there is no system of Ordnance in Europe, whose merits are known, or which has been accepted as a system. We have in this country the Rodman system of smooth bores, which has been tested through all calibers, except the 20 in., with results which have given, as yet, no instance of failure. If we are unable to assert that it is superior to any other, we can at least assert a tolerably accurate knowledge of what it is capable, which is more than can be said of any European system. The Ordnance question in this country is not between the Rodman system and a better one, but between the Rodman and three or four whose merits are not determined. Meantime, as has already been stated, American constructors are confined to the possibilities of cast-iron, and in that restricted field American Ordnance is far beyond the competition of any foreign nation. Our irons are unequalled, our workmanship unexcelled, our accuracy of detail in the minutiæ of the process and the absolute certainty of our results, are as nearly perfect as it is possible to be. With the examples of England and Prussia before us, the Ordnance Department is reluctant to advise—especially at this juncture—the embarking upon that boundless ocean of expense, which seems necessary before it will be possible to arrive at an experimental determination of the superiority of wrought iron and steel cannon; and until those nations exhibit results corresponding in value to the enormous outpouring of money upon experimental guns which the last ten years has witnessed, prudence at least should admonish us to bide our time. Whatever the Krupp and Fraser guns may be, it is certain that they are not yet afloat, nor frowning from casemates: it is certain too that they will not menace us, until their builders know what they are good for. When that eventful time arrives, when other nations are prepared to adopt them and arm their batteries, afloat and ashore, with them, then, and not until then, will it be time to ask whether the Rodman system should be superseded. D.

STEAM POWER METERS.

From "Engineering."

There are probably but few of our readers who, being employers of steam power, have not at some time or another desired to ascertain with exactness the total amount of work done by an engine in a given time when running with a variable load, and who have not been struck by the difficulty which exists in obtaining such information by any ordinary means. So long as the work performed by an engine is tolerably constant, indicator diagrams taken at frequent intervals, and carefully worked out, will give the desired information with sufficient accuracy for most practical purposes; but, except in the case of pumping or blowing engines, the work done by an engine is seldom really constant for more than a very few minutes together, and the consequence is that ordinary indicator diagrams, unless taken in rapid succession and in considerable numbers, do not afford data from which the total power developed in a given time can be calculated with any degree of accuracy. Moreover, the working out of a large number of indicator diagrams is a tedious task, and requires a considerable expenditure of time even if the assistance of a planimeter is available, and it thus but rarely happens that an attempt is made to ascertain with exactness the power developed by an engine doing variable work.

To facilitate the taking of a number of consecutive indicator diagrams, Mr.—now Sir Daniel—Gooch, many years ago employed, on the Great Western Railway, his continuous indicator, in which the diagrams were traced by the pencil on a continuously moving strip of paper: a plan which obviated some of the difficulties of the case, but which in no way diminished the labor requisite to obtain from the diagrams a knowledge of the power which the engine had been exerting. More recently also, Mr. Arthur Rigg, of Chester, has proposed and used a form of continuous indicator, which, although possessing one or two minor advantages over Mr. Gooch's, appears to us to be open to far more serious objections than the latter. According to Mr. Rigg's plan the cylinder of the indicator is placed in communication with the engine cylinder at brief intervals, the communication being allowed to remain open for, say, three revolutions out of every hundred; while the pencil carried by the piston-rod of the indicator bears against a strip of paper, which has a slow motion imparted to it by convenient means. The effect of this arrangement is that during the time that the communication between the engine and indicator cylinders is shut off, the pencil of the indicator will trace an atmospheric line on the paper; but when the communication is open it will rise and fall tracing on the paper vertical lines, which by their length indicate the maximum steam pressure and vacuum in the cylinder. These data being registered, it is intended to calculate the power developed by the engine by working out indicator cards taken from the latter, and having maximum steam pressures and vacuums equal to those registered by the continuous indicator. This method is in any case a very roundabout one; but in instances where the boiler pressure is constant, or nearly so, and the speed of the engine is controlled solely by the throttle valve, it may be possible by some considerable expenditure of time and trouble to obtain by Mr. Rigg's plan a tolerable approximation to the power developed by an engine in a given time. So soon, however, as we have to deal with an engine having varying expansion, Mr. Rigg's system becomes useless, as it is evident that of two diagrams, both showing the same maximum steam pressure and vacuum, the one may, from an alteration in the point of cut-off, correspond to the development of twice or three times the power shown by the other. Under these circumstances the maximum pressures and vacuums registered by Mr. Rigg's instrument would, of course, be of no use whatever.

In the case of engines fitted with Messrs. Farey and Donkin's arrangement for measuring the amount of heat passing away in the condensing water, the power developed in a given time can, as we explained in a recent number (*vide* page 341 of our last volume), be ascertained with a great degree of accuracy soon as the "constant" of the engine is known—the power developed and the quantity of heat passing away being sensibly proportionate to each other. But even with Messrs. Farey and Donkin's system some calculation is requisite, and although as an accurate test of the performance of steam engines it may be considered practically perfect, it does not form a ready means, easily applicable in all cases, of ascertaining the total work done in a given time by any engine, however variable that work may be.

The only instrument yet brought under our notice which satisfactorily fulfills this much to be desired end, is the steam power meter and continuous indicator lately designed by Messrs. Ashton and Storey, of Manchester, and which to our minds was the most interesting scientific novelty exhibited at the recent show of the Royal Agricultural Society. In this apparatus a modification of the inte-grating arrangement employed in General Morin's well-known dynamometer has been used to multiply the motion of the piston by the pressure exerted upon it, the result, expressed in foot-pounds, being by suitable mechanism indicated upon a dial. The general arrangement of this ingenious instrument is shown by the engraving which we publish in the present number, and we trust that the explanation of its construction there given will render its action clear. We believe that this instrument will be found to render material aid in estimating the economical value of different engines under various circumstances, and it will at once show whether any unusual expenditure of fuel is due to increased work thrown upon the engine or to carelessness upon the part of the attendants. It will also enable the user of the steam engine to ascertain, by mere inspection of the dial, the power required to drive different machines, or the efficiency of different lubricators, and it will furnish a variety of similar information, the value of which will be fully recognized by those who have hitherto only been able to obtain it by a considerable expenditure of time and trouble. Altogether we regard Messrs. Ashton and Storey's invention with much interest, and we shall carefully watch its progress. We shall be especially glad to know that it can be used on locomotives without the vibration giving rise to defective indications, and we trust that but a short time will be allowed to elapse before it is fairly tried under such circumstances. Once let it be proved that Messrs. Ashton and Storey's steam power meter can be depended upon to register accurately the actual work done by a locomotive during any given run, and those of our railway engineers who are inclined to make experiments, will have plenty of useful work on their hands for some time to come.

DESIGNOLLE'S NEW POWDER.

By A. Payen.

From "Bulletin de la Société d'Encouragement," through Polyt. Journal.

The introduction of the breech-loading ordnance and arms is a great progress in the art of warfare. But it is not less important to improve the moving agents and the moving power for projectiles, and to invent new kinds of gun-powder, the action and energy of which might answer the various wants of modern artillery.

The importance of this question was fully understood by Designolle, who, after incessant experimenting for seven years, seems to have arrived at its practical solution. In considering the actual condition of artillery it is evident that four principal kinds of powder are required:

1. Gun-powder.
2. A quick-acting powder for short-bore cannons.
3. A slow-acting powder for long-bore cannons.
4. A blasting-powder for torpedoes and exploding projectiles.

The ballistic power of the powder used heretofore, cannot be increased by altering the mixing proportions of its constituents.

The initial velocity imparted to the projectiles by the ordinary black gun-powder has been somewhat increased by the improvement of the machinery, by which the materials are prepared and mixed in the manufacture. This has been effected especially by the use of grinding-mills instead of stamping-mills. But the explosive or blasting power, which is injurious to fire-arms, has been increased by this change much more than the shooting-power.

The principal advantage of Designolle's system of powder-manufacture consists in the possibility of producing a whole range of different kinds of powder, varying in strength, and designated by different numbers, from 1 to 10, according to their strength. Also two entirely different classes of powder can be made by this system, a blasting-powder, the strongest kind of which is ten times more powerful than an equal weight of the powder now in use, and a gun-powder whose shooting-power is equal to that of the ordinary black powder, its explosive and destructive effect being however considerably less than that of the latter.

As either of these two classes contains ten numbers, differing in strength, it is evident that the system can answer any requisition.

Designolle has solved the problem of manufacturing a powder, the different kinds of which are suitable for different lengths and diameters of the bore of fire-arms and for different weights of the projectiles, and imparting to the projectiles an initial velocity as desired and as determined beforehand.

One principal constituent of Designolle's powder is picrate of potassium. The blasting-powder contains besides this only nitrate of potassium. The gun-powder is a mixture of picrate of potassium, nitrate of potassium and charcoal. These substances are mixed in different proportions, according to the strength required.

Picrate of potassium is composed of picric acid and potassa. Picric acid is a substance which was first discovered by Haussmann, in 1788. Welter afterwards obtained it by treating silk with nitric acid. A number of French and German chemists have made researches on the same substance. But it was reserved to Laurent to find out its exact composition and chemical formula, and to discover the most proper way of making it. He showed that the picric acid corresponds in its composition to phenylic acid, in which three equivalents of hydrogen are replaced by three equivalents of hyponitric acid.

$$\text{Formula: } C^{12} \left\{ \frac{H^2}{(N\,O^4)^3} \right\} O$$

A Paris gas company produces on a large scale phenylic acid which is the principal raw material for the manufacture of picric acid and of its compounds.

Picrate of potassium is a crystalline compound, consisting of small, glossy, yellow prisms of the dimetric system. It is insoluble in alcohol, very little soluble in cold water; but it can be dissolved in 14 parts of boiling water. When heated carefully to 300 degrees Celsi, it becomes orange. It, however, retakes its original color in cooling. When heated to 310° C. it explodes with vehemence.

This substance was very dear until lately, when John Casthellaz, one of the best French manufacturers of chemicals, improved its manufacture to such a degree, and produced it at such a low cost that the price of Designolle's new powder is but very little higher than that of the ordinary black gun-powder. To be able to determine the quantity of saltpeter and charcoal to be mixed with the picrate of potassium, it was necessary to examine the chemical reaction which takes place when this substance is made to explode. Designolle found, by numerous experiments, that two entirely different reactions can take place according to the circumstances under which the substance explodes.

1. When picrate of potassium explodes in the free atmosphere, prussic acid and nitric oxyde are formed.

2. When picrate of potassium explodes in a narrow place, as for instance in the bore of a gun. neither prussic acid nor nitric oxyde are formed, but the products are in this case: nitrogen, carbonic acid, hydrogen, oxygen, carbonate of potassium and carbon.

The formula which expresses the latter reaction, and on which the manufacture of the powder is founded, is as follows:

$$KO + C^{12} \left\{ \frac{H^2}{(NO^4)^3} = 3N + 5CO^2 + 2H + O + KO, CO^2 + 6C. \right.$$

Designolle's powder is made in the following manner. The different substances are at first mixed with 6 to 14 per cent of water, and crushed fine in a stamping-mill. Three to six hours are required for this operation. The mixture is then compressed in a hydraulic press. As the rapidity with which the powder burns or explodes is in an inverse ratio to the pressure to which it has been subjected, this pressure is taken differently, according to the different use to be made of the powder under treatment. This pressure varies from 30,000 to 100,000 kilograms. The compressed mass is corned by a special machine, sifted, polished and dried. The last two operations are done in the same way as with ordinary black powder.

There is, with the above exception, no difference in the mode of manufacture of the various classes and kinds of Designolle's powder. The proportions of the materials only are different according to the qualities that are required for the different kinds. The greater the amount of picrate of potassium in the mixture, the greater is the ballistic power of the product. Gun-powder ought not to contain over 20 per cent of the picrate. From 8 to 15 per cent of it are used for making cannon-powder, the exact quantity depending on the rapidity and vehemence with which the powder is expected to explode.

The advantages which Designolle's powder has over the ordinary gun and blasting-powder are the following:

1. Its ballistic or shooting-power can be increased without increasing its explosive force.

2. The strength of the powder can be exactly regulated within the limits given by the numbers 1 and 10.

3. The rapidity of action of the powder can also be exactly regulated.

4. The ballistic power of the powder can be increased without altering the mode of manufacture and in using similar materials.

5. The effects of the new powder are very regular and uniform. The initial velocity of the projectiles thrown by one kind of this powder is always the same. This velocity varies with different kinds from 1 to almost 2 meters, according to the mixture and pressure employed in the manufacture.

6. The new powder does not contain any sulphur, so that no vapors of sulphide of potassium or of sulphide of hydrogen are produced by its combustion, which vapors are very injurious to the health of the men when working in a casemate or in the interior of a man-of-war.

7. From the same reason the new powder has no injurious effect on iron, copper or brass.

8. The smoke produced by the combustion of the new powder is but very slight, and is in fact nothing but steam with small quantities of carbonate and oxyde of potassium.

Large quantities of Designolle's powder are actually manufactured in the French Imperial cannon-foundry at Bouchet; gunpowder as well as quick and slow-acting cannon-powder, and blasting-powder for torpedoes and for explosive projectiles. S.

METALLIC TUBES.—A new and promising industry is announced, that of the manufacture of metallic tubes from rolled plates, by machinery. The resources of the tube drawer have not been called into requisition for the production of stove pipes or speaking tubes, nor is it perhaps necessary that they should be. Heretofore they have been made cheaply by hand. We shall next week illustrate and describe a simple continuous machine whereby these and other varieties of tubes may be made, at almost insignificant cost for attendance, at the rate of sixty feet per minute. They are made from flat strips or skelps, with a continuous, longitudinal joint, wherein two continuous edges are lapped and locked together by pressure only. If the statements of the patentees may be fully relied upon, small (1-inch) copper tubes made upon this plan have withstood a pressure of 250 lbs. per square inch without leaking, and tubes of iron, zinc, tin, &c., considerable although less pressures. The joint can be formed either inside or outside of the tube, so as to present a flushed surface on either side as required.

Supposing such results to be fully established by continued practice, it is a question whether surface-condenser tubes could not be made with advantage by the same process. Some of the larger surface condensers, as those of the Hercules, have upwards of twenty miles of small, say, three-quarter-inch tubing. The pressure within them, where the steam is admitted to the outside, does not probably much exceed 25 lbs. per square inch, say 12½ lbs. due to the vacuum, 5½ lbs. for the head of sea-water above the condenser, and 7 lbs. for the force required to pump through the circulating water. Should there be the least leak at any point, the leakage would be of sea-water, charged, of course, with whatever air might be in mixture with it. It is a nice question, only to be settled by experiment, whether there would be any leakage, in tubes thus made by machinery, and subjected to a pressure of 25 lbs., and, if so, whether the leakage would be such as to materially vitiate the vacuum. If a tube should leak, it is not only a difficult matter to replace it, but it is even more difficult to find it among from 3,000 to 7,000 others. So far as a little leakage of salt water is concerned, it is by no means objectionable when it is considered that a little salt water is the very thing wanted at intervals in boilers working with surface condensers. If the salt water does not enter the condenser, it has now and then to be pumped in from the sea. In the latter case, however, the supply is known, and under control, while in the former it may be anything or nothing.

If mechanically jointed tubes should be found available for surface condensers, as possibly they may be, it will be urged that the laps of the joints represent so much excess or waste of metal, and that the rolled metal, with which the process commences, must cost more than the cast metal employed by the tube drawer. It will remain to be seen how much thinner metal may be employed in rolled plates than that to which tubes of the same strength may be drawn, and there is again to be considered the great economy of manufacture in the new process as compared with the slow and tedious process of drawing. We intend to offer no opinion upon these points, but to await the results of careful experiment, results which will probably be soon forthcoming. The members of the Institution of Mechanical Engineers are likely, we understand, to have an opportunity of seeing the machine at work during the approaching meeting at Newcastle, and we shall, as we have said, illustrate and describe it in our next number. It is the invention of an American, and is being introduced into England by Mr. T. F. Taylor, of No. 9 Doughty-street, Mecklenburgh-square, and 42 Kirby-street, Hatton-garden.—*Engineering.*

THE HIGHWAYS OF NATIONS.

From "The Engineer."

With the introduction of steam, and its application to locomotives and marine engines, came the race between land and water, which should constitute the principal routes of international communication. So far as the actual distance between any two emporiums of traffic and commerce is concerned, the land has the advantage of the water in the ratio of three to one. In other words, a journey by land of three hundred miles could be accomplished by rail in the same time as one of a hundred miles by water, even supposing our fastest ocean going steamers performed the voyage. The odds are still further increased in favor of land journeys if we take into consideration the general disinclination of passengers to sea voyages, and the troubles, delays, and anxieties that are the inevitable accompaniments of those that "go down to the sea in ships." These objections do not apply with the same force to the transport of merchandise, but they are not completely invalid even in that instanee. The difference between ocean highways and similar inland routes may be briefly expressed by saying that by the former we go round the world, by the latter we go across it. A glance at the map of our own little island is sufficient to demonstrate this fact, but to appreciate it fully, and to apply the simile upon a scale of magnitude commensurate with our title, we must lay before us the railway maps of Asia and America. There we see lines stretching from coast to coast, traversing deserts, forests, and prairies, and uniting opposite seas by a medium of communication not their own. In India, the port of Beypoor, on the west, is linked to that of Madras, on the east, by a railway which runs right across the southern portion of our oriental peninsula, and Bombay and Calcutta, the city of palaces, will soon be *en rapport* by the same means. But these, and other great national arteries of commerce and civilization, sink into comparative insignificance before the gigantic chain which now stretches from New York to San Francisco. If the status of our own country reached its climax almost before the introduction of what are now recognized as the pioneers of civilization, what must be the future of the new world where the same advantages have throughout the greater portion of its vast extent preceded the advent of the population?

To unite country to country, nation to nation, and continent to continent, by a more intimate link than ever previously existed, is the mission of the age; and insomuch as the common interests of the last exceed those of the former, so much the greater is the merit due to the accomplishment of the union. As an example of our meaning, the Mont Cenis tunnel will effect the union of France and Italy, and, without indulging in metaphor, undermine the glory of both Hannibal and Napoleon. But this is but a link, locally considered, between two adjacent countries, whereas the piercing of the Isthmus of Suez accomplishes a more direct communication between Asia and Europe than the two continents have ever previously enjoyed, and constitutes in every sense a highway of nations. It might be supposed that those ports and towns forming the termini of a route of this nature would benefit more largely than others situated more remotely from its vicinity. To some extent this supposition is correct, but not to the degree usually assumed. It is impossible at the present time for one nation to become rich at the expense of another, or to benefit exclusively by the magnitude of its imports. The days of national monopoly are gone, never to return. Increase of imports signifies increase of exports, and it is only now by an interchange of traffic and commercial relations that a country can hope for a prosperous future. Projected, advocated, and carried out by a Frenchman, it would be but a fair return for his nation to reap the most substantial advantages from the maratime canal. May it be so, the more especially as we are perfectly convinced that any stimulus and increase that may be given to the trade of our neighbors will not fail to be nearly equally valuable to ourselves. At the same time it is well not to be over confident. Disappointment is ever in direct proportion to expectation. Will the hopes of our Gallic friends be fully realized?—Will the results equal their anticipations? Will the opening of the new route restore to the old "highways" their former traffic? Shall Venice rise to her pristine glory, where she "sits enthroned upon her hundred isles?" Shall the lion of St. Mark again be the lord of the Adriatic? and shall the merchandise of India and Asia be wafted to the ports of the Mediterranean?

In former times a sailor who had doubled the Cape was regarded as a tried navigator, and considered competent to give his opinion and hold his own views with his nautical *confrères*. The scientific manner in which vessels are handled at the present day, and the large increase of steamers, have in some measure destroyed the value of the old test, but still rough weather is generally looked out for near that locality. Practically speaking, the value of the Suez Canal to the sailor is that, if successful, it will obviate the necessity of the passage round the Cape of Good Hope, and reduce the length of the voyage nearly one-half. The junction of two seas that is effected by the Suez Canal has long been endeavored to be accomplished in the regions of the new world. No less than seven different lines of canal have been projected and roughly surveyed in order to discover a highway between the Atlantic and Pacific Oceans. The value of such a work did not escape the penetration of the great adventurer and discoverer Hernandez Cortes, but from his time until now, with the exception of a railroad across the Isthmus of Panama, the communication has remained *in statu quo*. A ship canal in this situation would open a new route to Australia, China, Japan, and the adjacent countries—would do away with the passage round Cape Horn, and be an invaluable benefit to the commerce of the two hemispheres. At present it appears to be an impossibility to construct this important channel without the intervention of several locks. These would be fatal to the enterprise, as to attempt to pass the traffic of the world through a number of locks is an absurdity which the most reckless speculator could not ignore. Important as some of the routes are to which we have briefly alluded, they are nothing to those which remain to be opened up. China is still a country where the "iron horse" has never run. The boundless plains of Thibet and the wilds of Tartary, in their almost immeasurable expanse, are ignorant of steam locomotion. The great Asiatic highroads have yet to be delineated by lines of iron; the caravan must be replaced by the railway carriage, and the canal by the engine.

CONCRETE BUILDING.

Mr. Goodwin, builder of a concrete warehouse in London, communicates to "the Builder," the following account of the structure and materials: The concrete is composed of one part of best Portland cement to seven parts of material consisting of clean Thames gravel, crushed slag and clinkers from furnaces, crushed bricks, stone chippings, oyster-shells, pottery, hard core from dust-yards, and any other hard and incombustible material I could get. We built upon an average per day about 12 in. all round the walls, grouting in with sand and cement at every fresh layer of concrete. We also put in hoop-iron bond at each floor. We could have built 18 in. per day, which is the depth of the apparatus, but I considered 12 in. quite fast enough for a building so high; though at other smaller jobs I have often built 3 ft. per day.

The building is 70 ft. by 50 ft., and 60 ft. high. It consists of basement and five floors, each floor supported by twelve iron columns. The roof is of concrete 3 in. thick, laid between tee-iron 3 ft. 6 in. apart, covered with asphalte. The thickness of walls is to the brick rule; those 70 ft., two floors 27 in., two floors 22 in., and two floors 18 in.; the 50-ft. walls are, two floors 22 in., and four floors 18 in. The cost of the walls, considering I got a great deal of the material for nothing, was under £6 per rod; or, take the whole of the building as a cube, the cost was about 3d. per foot. It is very strongly built, and as good as one of the warehouse class can be. It is now loaded with goods, every floor full, and has never shown the slightest crack or settlement. It is harder than most kinds of stone used for building purposes, and is of one solid mass from beginning to end.

As with Mr. Tall's patent apparatus (with which it was built) a perfect surface is obtained throughout, it requires only a thin coat of cement and sand to finish the walls perfectly smooth and true. I quite agree with Mr. I'Anson in his opinion "that the success of such work depends on the entire honesty of the man who does it."

I have learnt so much of concrete with this and other contracts I have taken since, that I find the greatest care must be used in choosing the material. I have made specimens of all kinds. Many persons, and amongst them builders, think if they have gravel, by adding the cement they have all that is required to make concrete. So much depends upon the gravel, that if it is not the right sort the work will cost as much as brickwork, and then never be sound. Every bit of loamy matter and dirt must be washed out thoroughly; then you must replace with clean sharp sand, about one-fourth.

Those who wish to build of concrete should only do so where the material is on the spot or very near. Clean river ballast, with a good proportion of sand, is as good a thing as we can have for Portland cement concrete. If some crushed slag or furnace clinkers can be mixed, so much the better; it is also lighter, which is a good thing in wall construction. Burnt clay is also a very good material, provided it is well burnt. Great care should be taken to sift with a fine sieve all crushed material; for, let it be what it may, dust, loamy matter, or fine sand, if it is finer than the cement itself it will dilute and kill it. I have made specimens of concrete with gravel that have become as hard as the best stock brick, and I have made others, with the same proportion of cement, that you may crush and crumble in your hands.

The concrete chapel I have just completed at Snaresbrook, in Essex, is built of the refuse of the brick-fields, mixed with sharp sand got from a good depth, there being a sewer in course of construction close by. The concrete is composed of one part cement to seven parts of material. The prime cost of the walls, including the working the apparatus, was £7 per rod. Many of the statements that have appeared in print upon concrete are not correct. It has to be borne in mind, a yard of concrete mixed dry, when wetted and put into the apparatus, falls considerably short of a yard,—at least 15 per cent. Neither does the cement make bulk, but disappears in measure, as does the water. If lumps of stone can be got, or brick burrs, or old bricks, to pack into the wall, it makes better work and cheaper. The more the cement can be displaced the better for the work and the less the cost.

Great care should be taken the cement is not too fresh, or it will cause the work to crack. It should be at least a month old before using.

The concrete villa at Addiscombe-road, Croydon, is now completed and occupied; it gives great satisfaction, and, it is said, will be the only house the rain will not penetrate in that neighborhood. The lower floors are all of concrete, and perfectly smooth and warm; there is no channel for a mouse or any creeping thing in that house, unless it take up its abode with the family.

THE SIEMENS-MARTIN PROCESS.

Abstract of a paper read by MR. RICHARD HOWSON, before the Iron and Steel Institute.

After some remarks touching the history of the mode of manufacturing cast steel by melting certain proportions of cast iron and wrought iron together, the writer proceeded to observe that it was not till 1845 that the process assumed a practicable shape. In that year Mr. Heath obtained a patent, the specification of which clearly describes how such a process may be carried out in the hearth of a reverberatory furnace. We have no record that his experiments led to commercial success; probably there were difficulties in the way. At a later date other workers came into the field, and in the hands of Mr. Attwood the manufacture has reached a fair degree of certainty and excellence, to which the use of Siemens's furnace has doubtless in a great degree contributed. Meanwhile, in France, the Messrs. Martin were prosecuting experiments in the same direction and on the same principle as described by Heath, and were successful. Their method of proceeding, however, introduced some new features, especially the use of oxides. The staple trade of their establishment at Sircuil is the manufacture of gun barrels, which they turn out of excellent quality from pig iron and puddled ball, which are both the produce of a pure African ore. The process may be simply described as follows: The pig iron is first melted on the hearth of a Siemens furnace, in weight from $\frac{1}{2}$ ton to 1 ton. The puddled ball (previously heated) is then added in quantities weighing about 1 cwt. at a time, with occasional small doses of oxide of iron of pure quality. By these means the carbon in the bath becomes gradually reduced to a low percentage, and the metal approaches to the state of wrought iron. A portion of the carbon is then restored by the addition of spiegeleisen, so as to give the steel the requisite temper, and the process is finished, and the whole is tapped off into ingot moulds. The ingots are subsequently hammered, rolled, and forged into gun barrels. The time occupied from charging the furnace to tapping out is about 11 hours, and the average proportion of cast and wrought iron will be about 2 of the former to 3 of the latter, with usually 2 or 3 per cent of oxides. At the Newport Works the experiments which have been made are very numerous. The next portion of the paper was devoted to a detailed description of the apparatus, and then went on: The rationale of the process next comes under notice, the state of the bath being judged of at different periods by means of tests which are from time to time taken out. After the pig iron is melted, the first action which takes place is the oxidation of the silicon. The fracture of the test is then white, like refined iron. As more wrought iron is added, it becomes more or less malleable, and the fracture assumes a dull, gray color, getting gradually brighter and more compact in grain, until it reaches the stage of true steel. At this point the process might be stopped, and has been stopped, with good results; but it is not always safe to do this in practice. The better plan is to proceed until the tests begin to bend and tear, and then to impart the requisite hardness by adding spiegeleisen, about 1 cwt. to the ton being usually a sufficient quantity, with brands containing 6 or 7 per cent of carbon. The experience at Newport has shown that little improvement is to be gained by deviating from the practice adopted by Messrs. Martin themselves, and it has also decided another question, viz: that the process offers little or no chance for the employment of low-priced iron. As a rule, the present brands produce the best ingots, and it is much to be regretted that Cleveland iron, except in the state of very carefully puddled bar, seems to be quite inadmissible. The author spoke favorably of the economy of the process and of the possibility of its standing the severe competition in England; and went on to notice two points of interest contingent to the process. In the first place, he said it had been found that when the bath had arrived at the soft stage, there was considerable danger in allowing it to remain any lengthened period before adding the spiegeleisen. As long as there was a sufficient amount of carbon in both, it acted as a protection to the iron against oxidation; but when it was all, or nearly all burnt away, the iron itself began to burn, as might be seen by the crystallized appearance of the fracture. It was a question, however, whether it was the free oxygen of the flame alone which produced this result. Professor Graham had shown that carbonic oxide penetrated iron with extreme facility; and specimens were shown which had been subjected to the action of carbonic oxide under a variety of conditions. They all presented the same appearance of deteriorated structure; and were all excessively brittle. Neither carbonic acid nor atmospheric air under similar conditions seemed to have the same effect; and it might be fairly assumed that this question required further examination. The other point to which he referred was a peculiar property of homogeneous iron or mild steel, which was early observed in the course of the experiments at Newport. When ordinary steel was chilled in cold water at a red heat, it hardened more or less according to the percentage of carbon it contained. When the carbon was reduced below a certain amount—about 5 per cent—it then obeyed the same law as copper. The metal when chilled became soft to the file; but, at the same time, more compact, tougher, and stronger. Specimens were exhibited to illustrate this fact; and the question was glanced at as to the probability of hereafter turning this property to useful account. The writer concluded by stating that much remained to be done in the metallurgy of iron and steel; and ventured the prediction that steel ingots for rails would yet be made at a price but little exceeding that of puddled bar, although he acknowledged that whoever undertook to do it would have to bring to the task a large stock of patience, perseverance and capital.

THE STRENGTH OF BOILERS.—It has been found, by actual experiment, that good forged iron will bear a strain of from 25 to 30 tons to the square inch of section. That is, a bar one inch square, or a plate of iron containing one inch of sectional area, will require a force of from 50,000 to 60,000 lbs. to wrench it asunder. Some years ago, a committee of the Franklin Institute of Philadelphia very thoroughly investigated this question of the strength of boil rs, and it was found that the tenacity of boiler-plate increased with the temperature up to 550°; at which point the tenacity began to diminish. At 32°, the cohesive force of a square inch of section was 56,000 lbs.; at 570°, it was 66,500 lbs.; at 720°, 55,000 lbs.; at 1,050°, 32,000 lbs.; at 1,240°, 22,000 lbs.; and at 1,317°, 9,000 lbs.

Strips of iron cut in the direction of the fiber were found to be about 6 per cent stronger than when cut across the grain. Repeated filing and welding was found to increase the tenacity of the iron, but the result of welding together different kinds of iron was not found to be favorable. The accidental overheating of a boiler was found to reduce the ultimate or maximum strength of the plates from 65,000 lbs. to 45,000 lbs. per square inch of section, and riveting the plates was found to occasion a diminution in their strength of one-third. The results of M. William Fairbairn's experiments differed somewhat from the above. He found that boiler-plate bore a tensile strain of 23 tons per square inch of section before rupture; which was reduced to 16 tons when joined together by a double row of rivets, and 13 tons, or about 30,000 lbs., when joined by a single row of rivets (2,240 lbs., are allowed here for a ton).

Mr. Fairbairn says that "plates when riveted together are reduced in strength from the fact that nearly one-third of the material is punched out for the reception of the rivets," and therefore he takes 34,000 lbs. as equal to the strength of riveted plates containing one inch of sectional area.

In casting up the bursting pressure of boilers, it is necessary that some number representing the tenacity of plates one inch thick be decided upon. Some engineers in their calculations estimate it at 34,000 lbs. while others place it as low as 25,000 and 30,000 lbs. These figures suppose the iron to be of the best quality, and the following rules suppose the workmanship of the boilers to be first-class in every particular. No rules can be given for poor materials, nor for poor workmanship. By a sectional inch or an inch of sectional area is understood a sufficient surface of boiler-plate of any thickness under 1 inch to make a thickness of 1 inch; or, in other words, suppose a boiler to be constructed of ½-in. iron, and from its end we cut off a section or hoop 1 in. long, two such sections would be equivalent in quantity of iron to one hoop 1 in. thick, for the two being each ½-in. thick would together be 1 in. thick. If the boiler was constructed of ¼-in. iron, it would require four such sections to make one an inch thick. If constructed of $\frac{3}{8}$-in. iron, 2.66 would be required, and so on for any thickness of plate. In testing the strength of iron, bars 1 in. square are used; hence, in estimating pressure on boiler-plates, sufficient surface must be taken for each thickness to equal in quantity a bar of iron 1 in. square. If we assume that single-riveted boilers will sustain a tensile strain of 34,000 lbs. per square inch of section before rupture, the strain on each superficial inch on a plate $\frac{3}{8}$-in. thick would be $\frac{3}{8}$ of 34,000, and for $\frac{1}{4}$-in. plate $\frac{1}{4}$ of 34,000, etc.—*The Locomotive.*

BETTER IRON RAILS.

We promised in a previous number some facts about the superior durability and economy of thoroughly worked iron in rails, and the practicability of obtaining good rails at a reasonable cost. The case of the Reading railway, to which we intended to refer, and the whole issue between railway managers and rail makers, is thus stated in the New York "Times."

Whenever a broken rail throws off a train or the enormous cost of maintaining permanent way is under discussion, there is a general outcry against the poor iron of modern production, and a longing for the skill, science and honesty among manufacturers that used to make rails last twenty years. Nothing can be more touching than the pious regrets of a railway manager, standing among the *debris* of rails, axles and machinery worn out in the flower of their youth, at the degeneracy of the metallurgical skill and conscience of the period. In order that the public may understand how far their risks of life and loss of dividends are due primarily to this cause, we invite their attention to the following facts and considerations.

The general rule in this country (to which there are indeed exceptions) in regard to the purchase of railway materials is simply this: buy the cheapest. First cost is the controlling and often the only question entertained. The nature of the materials and processes to be used in the manufacture of rails, for instance, are not mentioned. The buyers for some of our roads, especially new roads, never make the slightest allusion to quality, and never specify tests and inspections, but simply go about among the mills, comparing and beating down prices, and accepting the very lowest. More than one of our rail makers are to-day rolling, under protest, rails upon which they decline to put their trade-mark—rails made from the very cheapest materials, in the very meanest manner—for all that is required is that they shall stick together till they are laid. And if American makers will not roll them, Welsh makers will. The late report of the State Engineer of New York says: "American railway managers, instead of offering anything like a reasonable price for good iron rails, have made themselves notorious by establishing as standard, a brand of rails known all over the world as 'American rails,' which are confessedly bought and sold as the weakest, most impure, least worked, least durable and cheapest rails that can be produced." The State Engineer refers in confirmation of this opinion to the statement of Mr. A. S. Hewitt, United States Commissioner to the Paris Exposition, a statement not yet controverted; and to a statement of Mr. Sandberg, an English engineer of note, in the London *Times.* A leading American railway president and reformer has publicly said: "There is a fear on my part that railway companies will themselves tempt steel-makers to send a poor article by buying the cheapest—first cost only considered—*as they did with the iron-masters.*"

There is also a class of railway managers who pretend, and possibly believe, that they cannot get good iron rails—that the existing processes for cheapening iron in all stages of its manufacture render it impracticable to produce the uniform and excellent material formerly made. Now, while it is true that much poor iron is called for and sold, it is notorious that a better knowledge of chemistry and the modern improvements in machinery enable iron-masters to produce a more excellent and uniform material than ever before, as well as to reduce its cost.

These general facts are well enough known to those who have taken the trouble to inquire. But we are not confined to general facts. There are particular cases that cover the whole issue. The one we shall mention now is, fortunately, of such a character that no private interest can affect the statement or be affected by it. Early in 1868, the Reading Railway Company commenced rolling their own rails by an improved method, and some of them have already been down long enough, under the immense coal traffic of that road, to vindicate this policy. For instance, out of 9,000 tons of home-made rails, which had carried a certain traffic during the last nine months of 1868, only five tons, or one in 1,800 tons, had worn out. During the same time, and under the same traffic, out of 2,000 tons of rails made by the old process at an outside mill of good repute, about 200 tons, or one in ten, had been worn out and removed, and the indications are that the remaining 1,800 tons will be unfit for use at the end of this year. At a point in the road near Reading, where shifting from connecting lines is added to the regular tonnage, the life of rails made by the various old processes is from three to four months. Some rails only last six weeks. At this point the rails made by the new process have already been down sixteen months and are still sound, although much worn. The trouble with ordinary iron rails, as we have explained on another occasion, is that they go to pieces before they get a chance to "wear" out.

The best iron rails cost perhaps twelve to fifteen dollars per ton more than the poorest, but if they last twice or thrice as long, no railroad manager will pretend to doubt their economy. The trouble is, that some railroad managers, and especially the builders of new roads, never consider the question of durability. Nor is there any secret or difficulty in the manufacture of good iron rails. One process, which makers are sometimes forced into by low prices, is to cut up old rails, pile them together and roll them into slabs to form the head of a new rail. The remainder of the pile from which the new rail is rolled, is simply old rails cut up and laid together. Not a particle of new iron, which would greatly help the welding, is added, for that costs some six or seven dollars per ton more than old rails; and not half work enough is done on the loose bundle of iron forming the rail pile to compact it. Nothing is more certain than that such rails will go to pieces in the welds after short service. The method adopted by Mr. Coxe, of the Reading Railway Company's mill—and the same or a better one would be gladly adopted by private makers if companies would pay for it—is as follows: Some 70 per cent of old rails and 30 per cent of new iron (puddle-bar) are laid into a pile and rolled into slabs an inch thick. Nine thicknesses of these slabs are again piled, reheated and rolled into a headpiece two inches thick, which forms the top of the rail pile. The remainder of the pile is made up of seven thicknesses of the slabs before mentioned, the whole being heated and rolled into a rail.* In this way the body of the rail is twice compacted by heat and pressure, and the head, that receives the direct action of the car-wheels, is three times subjected to this condensing operation.

A rail thus made, instead of being a bundle of heterogeneous laminæ stuck together by cinder, and ready to split apart under the hammering of wheels, is a dense, compact, and comparatively homogeneous mass, which offers resistance not only to abnormal splintering, but to normal abrasion and wear, just in proportion to the work put upon it in the rolling mill. It is the perfect homogeneity of steel that enables it to outlast the best iron, even more remarkably than the best iron outlasts the poorest; and the nearer iron rails approach in structure to steel rails the longer will they last, and the less will they cost in the end.

It is time that this pitiful talk about the impossibility of getting good rails was stopped. There is no doubt that some railmakers "scamp" their work—a peculiarity of the period not confined to rail-making—but the worst of them can and will make good rails, if railway managers will give them a chance and institute suitable tests and inspections.

THE WERDER RIFLE.

Translated from "Polyt. Journal," by DARAPSKY.

The Bavarian government has proposed to the Chamber of Deputies to adopt the Werder rifle, together with the Berdan cartridge, for use in the Bavarian army, and to order for the present 100,000 of them. A Berlin military periodical contains the following description of the rifle mentioned: Werder's rifle is a breech-loader, simple in its construction and of small caliber (11 mil.).

The breech-mechanism has some resemblance to that invented by Peabody. The breech-block moves on an axle passing through to back part of the block at a right angle to the bore of the gun. When the breech-block is turned downwards, the breech opens, when turned upwards, it is closed. The Werder breech-block has a forked projection behind its axle. A concavity on the upper surface of the block receives the cartridge in loading.

The extractor has the shape of a joint-lever and takes hold of the cartridge from two opposite sides. The breech-block, in being turned down, sets the extractor in

* The pile is repeated after being reduced to $5 \times 6\frac{1}{2}$.—ED. V. M.

motion. A spring brings the latter back in its ordinary position. The striker is situated within the breech-block, and is retained there by a spiral spring, which also draws the striker back after each discharge of the rifle. A feature which distinguishes the Werder system from that of Peabody is this, that the breech closes of itself when the rifle is cocked. Before this is done, the breech is kept open by a double spring attached to the above-mentioned forked projection at the back of the breech-block. During and after the discharge of the rifle the breech is kept closed by a support on which a projection at the front part of the breech-block then rests. When this support is removed the breech opens again. This support is movable round the same axle to which the trigger is attached, its motion being however independent from that of the trigger. The motion of the support is effected by an arm which passes through the trigger-plate, and which ends in a finger situated within the trigger-guard in front of the trigger, but bent in an opposite direction.

The lock consists of the following parts: the cock, the main-spring, the trigger with the sear, and the trigger-spring. The cock moves within a slot in the back part of the breech-block. The thumb-plate is on the right side of the lock.

When the cock is being made ready for shooting, an arm connected with it and provided with a small roller, pushes the breech-block upwards, thus closing the breech.

All the axles rest on the two parallel cover-plates of the lock. The whole mechanism is contained in a quadrilateral case screwed on to the barrel. The same screw which holds the trigger-guard in place, also serves to fasten the breech-mechanism to the case.

The whole mechanism, above described, works in the following manner. When the rifle is cocked, the breech closes of itself. When the trigger is pulled, the cock acts on the striker, and the latter on the priming. After the discharge of the gun, the breech is opened by a slight forward movement of the index of the right hand. By this movement the index leaves the trigger and touches the finger of the arm connected with the support of the breech-block. The support is turned off, and the breech-block sinks down, owing to the action of the double spring attached to the forked back part of the block. Thus the breech is opened. At the same time the extractor is set in motion by its own spring, and the case of the cartridge is removed. All this is done in one moment, during the short time when the shooter takes the rifle down from his cheek. The new cartridge laid into the concavity on top of the breech-block then slides into the barrel. In cocking, the breech closes again, and the rifle is ready for shooting.

The rifle being in this condition, a pressure applied by mistake on the finger of the arm connected with the support, would not be of any consequence, because the support is then kept in place by a projection of the cock, provided for the purpose. This arrangement prevents the breech from being opened prematurely. If required, the lock can be set at rest. For the use of this rifle the following manipulations are necessary:

1. Pulling the trigger.
2. Opening the breech, which is done by a slight movement of the index.
3. Introducing the cartridge.
4. Cocking.

If it is intended to keep the breech closed after the discharge of the rifle, the finger connected with the support of the breech-block has to be left untouched.

To draw the charge, the cock must be relieved slowly and carefully. After this the trigger is pulled, the breech opens and the cartridge is thrown out of the barrel, through the action of the extractor.

To take the lock apart, the screw of the trigger-guard is removed, the breech-mechanism is lifted out of the case, the left cover plate is taken away. After this the lock is free, and the three springs and the other parts of the lock may then be removed without the use of any kind of instrument or tool. The stock of the rifle is one piece of wood, and has a rectangular recess to receive the lock. The weight of the whole rifle is $8\frac{1}{2}$ Zoll lbs. (1 lb. = $\frac{1}{2}$ kilogram). Its length is 50 inches of Rhenish measure. The rifle is provided with a sword-bayonet, and with a stairs-sight. The cartridge is pressed from copper with a central prime. It has been designed by Uttendörffer, at Nuremberg. 4.3 grams of powder are used for a shot. The projectile is partly cylindrical with two channels; it is oval in front and has a cavity behind for expansion. It weighs 22 grams. The case of the cartridge is conical. A coppered-iron plate of a somewhat larger diameter than that of the case, is soldered to it, and serves as a hold for the extractor. A ring of thick pasteboard is placed on the bottom of the case, inside. A small cup of brass containing the cap, and a small piece of brass is situated in the middle of this ring. It is to be seen from this description that this cartridge is a combination of Boxer's priming arrangement and of the American case-construction.

The Werder rifle, owing to the simplicity and ingeniousness of its construction, can be fired in rapid succession. The manipulations necessary for shooting cannot easily be more simplified and shortened by any other mechanism imaginable.

Well exercised soldiers have fired 14–15 times per minute, when they had to take the cartridges from their pouches. First-class riflemen at Amberg have fired 18 times in one minute, hitting each time the target, the latter being 4 ft. wide, 9 ft. high, and placed at a distance of 200 paces. A considerable advantage of Werder's rifle is the great facility with which the lock may be taken apart, a facility which every rifle for military purposes ought to possess. The whole construction is perfectly solid and strong, thus excluding all danger or mishap from breakages. These and other remarkable qualities of Werder's rifle and of the cartridges used with it, as well as the results of experiments made with both, are set forth in the military periodical of Berlin, all of which show that this rifle is one of superior excellence. S.

THE FIELD GUN OF THE FUTURE.

From the "Army and Navy Gazette."

Have we yet got the gun of the future—the gun that is to supersede all other weapons of its kind, which all men, be they Segmentites or Shrapnelites, followers of Boxer or believers in Armstrong, will acknowledge to be perfection, and join together in praising? The experiments in field artillery at Dartmoor have at length come to an end, and although the report of the committee is yet unpublished, not a little information respecting the results of the various trials has found its way in print. That much has been gained by these many experiments towards the solution of certain broad questions in the artillery science, there can hardly be a doubt, but that the information will, or can, be so condensed as to point out exactly what is needed for our field artillery we take leave to doubt. Even on the question of field artillery equipment for India it is difficult to arrive at anything like a definite conclusion, so many are the conflicting opinions on this head. During the recent experiments at Dartmoor, about 800 rounds were fired from their muzzle-loading bronze guns without drawback or accident of any kind whatever. The opinion of the committee, however, seems greatly in favor of a bronze field howitzer, as being a most desirable piece of ordnance for service. If we mistake not, the Indian artillery had formerly two howitzers in every field battery, and, although lighter than those now recommended, they were found to be most useful throughout all our great Eastern campaigns. The Russians have lately adopted bronze guns for their field artillery, and have also introduced a most formidable field howitzer of 6-inch caliber. The opinion of many Indian artillery officers seems to be in favor of a similar piece of ordnance being adopted in our own service, the more so as it would be attended with very little expense, there being numerous old smooth-bore bronze guns lying idle at Woolwich, which could very easily, and at a small cost, be converted into field howitzers. Whether any special recommendation on this head will be made it is impossible to say, but public opinion—that is artillery public opinion—goes far to make us think that for India the future field artillery will consist of muzzle-loading bronze 12-pounder guns, each battery having attached to it at least two formidable field howitzers of 6-inch caliber.

The science of field artillery, like that of every other military arm, is no doubt progressive, and is now in a state of transition. When infantry soldiers are armed with rifles that can hit a target the size of a man seven times out of ten at 1,000 yards, and when the men who handle those arms are gradually being trained to shoot with even greater precision, it is quite evident that field artillery must improve vastly both in the distance and exactitude with which it can do execution; otherwise every battery would be simply at the mercy of the first regiment of infantry that was pleased to make a target of the artillerymen, their horses and their guns. The experiments at Dartmoor have really proved the first preaching, so to speak, of this new artillery doctrine. The British public are very proud of their artillery, and have good reason to be so. But the said public is very much given to applaud what is, in these days at any rate, exactly the opposite of useful in artillerymen as gunners. To see field batteries galloping about, changing their front and opening fire with the most wonderful rapidity—limbering and unlimbering their guns with a quickness and a dash that seems wonderfully expert to all unmilitary men, are what the spectators delight in at reviews, and what give special correspondents occasion to praise greatly that of which they really know nothing. All this is pretty, looks well at Wimbledon or Aldershot, but it is not the real work of artillery. And this is the Dartmoor experiments, and more especially the report that will follow these experiments, must go far to dispel. Artillery ought certainly to be brought quickly into action, but once in action they ought to be in no hurry, and should remember that one round well placed is worth more than a dozen that have been fired at random. In a word, to use effectively field artillery the greatest calmness and precision is requisite. The first duty of the officer commanding a battery brought into action, is to ascertain his exact distance from the enemy. At Dartmoor many experiments as to the best means of working out this problem were made, but without any definite conclusion being arrived at. Some officers are in favor of telescopes being attached to the guns, others against the system; but there appears to be but one opinion respecting the necessity of instructing the gunners far more exactly than hitherto in the science—for it is a science —of judging distances correctly.— In a word, the Dartmoor experiments have proved that our field artillery must be exact, and that less care may be given to ensure dash, if more is given to create precision. They have also shown that we want a heavier field gun and more field howitzers than at present. In these days a campaign is finished in a week, and the times when a general could afford to halt for two or three days in order that his siege artillery might reach him, are gone forever. That, as yet, we have not the field gun required for service in these days of breech-loader rifles is very certain, and that we cannot afford to throw away the various guns we have made during the last ten years, is equally sure.— The Dartmoor experiments have at any rate taught us in what we are chiefly wanting in field artillery, and to learn this is something. But they have also shown very plainly that more deliberation, more experiments, and a considerable amount of patience are requisite before we can congratulate ourselves upon having found out the gun of the future, about which, before we begin to make it, let there, in the name of economy, be no doubt whatever. We have fallen into not a few ordnance pitfalls; let us beware lest we tumble into any more.

HYDROSTATIC STEERING APPARATUS.

From the "Mechanics' Magazine."

In designing the hydrostatic steering apparatus of H.M.S. Achilles, Admiral Inglefield has taken advantage of that great natural power which every floating vessel carries with it, viz.: the hydrostatic pressure of the water which sustains it. He thus has at his command an agent ready to be brought into action at a moment's notice. In such a vessel as H.M.S. Achilles, the pressure of the external water amounts to a load of about 8 lbs. per square inch at the level of the working cylinder, viz.: on the floor of the screw alley or the tunnel through which the screw shaft is conducted to the stern of the vessel. To move such a mass as the rudder of the Achilles against the resistance of the water when the vessel is going at 14 knots per hour requires very considerable power, and the problem to be solved was how to utilize the constant pressure of 8 lbs. per square inch, magnifying it so as to obtain sufficient force to overcome the resistance of the rudder. We will describe the manner in which this is effected by the Admiral, remarking that similar machinery may be adapted to any vessel.

A large cylinder, fitted with a piston and slide valve like that of a steam engine, is fixed horizontally in the lowest available part of the vessel. The external water is admitted to this cylinder through a Kingston valve guarded by a sluice valve. A powerful water engine is thus formed, ready to be set in action as occasion may require. Special arrangements for working the slide valve with unfailing certainty have been applied. A barrel is fixed at each end of the cylinder, and the piston rod extending on either side of the piston works in these barrels, which thus form powerful hydraulic pumps. These pumps are connected by pipes with two hydraulic cylinders fixed one on either side of the tiller on the lower deck. The rams of these cylinders are connected together by a crosshead carrying a strong steel pin entering a block, which slides in a groove attached to the under side of the tiller. Thus the tiller can traverse its full arc in either direction, while the rams move rectilinearly to and fro. The water in its course from the hydraulic pumps to the tiller cylinders passes through a valve box fitted with a regulating or directing slide. This slide is worked by a rod extending upwards to the wheel house on deck, and passing downwards to wheels on the lower decks, one of which may be on the screw alley far below the water line. The wheels are worked by hand like an ordinary steering wheel, one man moving them with ease. When the wheel is in its middle position the water is cut off from the pumps, but the two tiller cylinders communicate freely; thus the rudder is left free to right itself. By turning the wheel through one-third of a revolution either way, the water pressure is turned on to one or other of the tiller cylinders, and the rudder is put hard over to port or starboard as may be required. When the wheel is turned only half its stroke in either direction, the water is locked in the tiller cylinders, and thus the rudder is held fast in the position to which it had been brought.

It will thus be seen that one man at either of the steering wheels does what it requires generally twenty-five men to do at the ordinary steering wheel. By means of the sliding block, acted on by a hand screw on the tiller, the hydraulic apparatus can be disconnected in less than a minute, and the tiller can thus be left free to be worked in the ordinary way; but this is not necessary, for by putting the directing slide in its middle position the tiller is left quite free, and can be worked by the ordinary steering wheels and tackle, which need never be disconnected. Thus the hydraulic steering gear may either act independently, or it may be employed as a force auxiliary to the men without in any way interfering with the normal condition of the steering apparatus. It may be readily understood from the construction that the working power acts only when it is wanted. When the rudder has to be moved, the hydrostatic cylinder or water engine acts. When the rudder is fixed in any position the water engine ceases to move, but remains ready to start into action the moment it is required with its full force. Our readers will now understand the general construction of the apparatus which has been found so successful in H.M.S. Achilles. We need scarcely say that there were numerous details of construction which required great consideration in applying it. The whole apparatus, however, is extremely simple, easy of application, and not liable to derangement from accident or wear. We understand that it is cheaper than any other mechanical steering apparatus yet tried. The power which it utilizes costs nothing, and is always ready to hand for use. These points, taken in conjunction with its success in the Achilles, should be the means of opening the eyes of the Admiralty authorities to its value.

DUROMETER.—An instrument for determining the hardness of metals has been invented by a French engineer. It consists of a drill, turned by a machine of a certain and uniform strength. The instrument indicates the number of revolutions made by the drill. From this, compared with the length of the bore-hole produced, the hardness of the metal is estimated. It is said that most rails are tested in France by this instrument.—*Steierm. Industrie u. Handelsblatt.*

THE "STONEWALL" DISASTER.—The question arises, what is the use of legislation, or of government, as far as the safety of passengers is concerned, when naked candles are allowed among bales of hay, when a vessel provided with the legally required pumps can incontinently burn up, when the boats and life-preservers certified to be sufficient and in order, do not save the passengers from drowning, and when the destruction is as complete as if there had been no life saving appliances at all?

It seems simply criminal on the part of those who have the power, to allow boat after boat, and their thousands of passengers to be destroyed by fire or collision, when the whole boiler power of the vessels could, if the proper pumps, injectors, or other *means of application* existed, drown any possible fire or neutralize any possible leak.

WORKING RESULTS OBTAINED AT THE NEUBERG BESSEMER STEEL WORKS.

BY G. KAZETL.

[As the Bessemer Steel Works at Neuberg, in Styria, are known as one of the best and most carefully managed establishments of this kind, we communicate in the following the working results obtained at these works in the years 1866 to 1869, as published in Oestr.-Zeitschrift, by G. Kazetl, special manager of the Neuberg Bessemer Department.]

I. *Materials Used.*

Year & half year.	Pig-iron.	Steel scrap.	FUEL. For heating converters and ladles. Soft charcoal.	Coke.	Coal.	FUEL. For heating boilers. Wood.	Small coal.	Lignite.	Cinders from reverberatory furnaces.	LINING MATERIALS. Quartz.	Clay.	Bricks, tuyeres, etc.
	Cwt. (Austr.)		Fass.*	Cwt.		Cords.	Cwt.			Cwt.		
1866. I..	18,719 00	....	3,083	1,892	......	1,041	......	....	....	1,283	343	382
II..	18,097 40	....	2,550	3,014	......	1,128	......	....	....	1,179	316	81
1867. I..	25,843 70	....	3,796	3,169	4	1,271	......	....	....	1,826	453	142
II..	25,251 60	....	3,170	3,636	......	1,057	......	....	....	1,535	402	117
1868. I..	32,136 90	....	4,170	3,204	......	1,360	......	....	....	1,869	503	155
II..	31,413 10	15 45	3,350	2,520	52	395	1,079	7,780	2,353	1,709	430	199
1869. I..	31,575 60	345 35	2,672	2,715	134	....	668	14,189	2,396	1,909	473	169

* 1 Fass = 7.78 cubic feet. All the measures and weights are Austrian.

II. *Products.*

Year and half year.	Number of charges.	PRODUCT. Ingots.	Scrap from pouring.	Scrap dis-ch'ged from vessel.	AVERAGE PERCENTAGES. Ingots.	Scrap from pouring.	Scrap discharged from vessel.	Loss.
		Cwt.						
1866. I...........	322	15,378 35	392 11	369 40	82.15	2.09	1.97	13.79
II...........	285	15,311 90	331 55	213 25	84.60	1.83	1.20	12.37
1867. I...........	385	21,847 25	352 15	494 75	84.53	1.36	1.91	12.20
II...........	362	21,599 90	315 15	586 75	85.53	1.24	2.32	10.91
1868. I...........	507	27,866 35	324 60	465 40	86.71	1.01	1.44	10.84
II...........	499	27,330 45	305 25	221 65	86.96	.97	.70	11.37
1869. I...........	495	27,635 50	161 05	174 45	86.57	.50	.54	12.39

III. *Materials Used on* 100 *lbs. of Ingots.*

Year and half year.	FUEL. For heating converters and ladles. Soft charcoal.	Coke.	Coal.	FUEL. For boilers. Wood.	Small coal.	Lignite.	Cinders.	LINING MATERIALS. Quartz.	Clay.	Bricks, tuyeres, etc.
	Cubic ft.	Pounds.		Massive cub. ft.	Pounds.			Pounds.		
1866. I.............	1.5	12.3	....	4.8	....	....	....	8.3	2.2	2.4
II.............	1.3	19.6	....	5.3	....	....	....	7.7	2.0	.5
1867. I.............	1.3	14.5	.02	4.2	....	....	....	8.3	2.0	.6
II.............	1.1	16.8	....	3.5	....	....	....	7.1	1.9	.5
1868. I.............	1.1	11.5	....	3.5	....	....	....	6.7	1.8	.5
II.............	.9	9.2	.20	1.0	3.9	28.4	8.6	6.2	1.5	.7
1869. I.............	.75	9.8	.48	....	2.4	51.3	8.6	6.9	1.7	.6

The manufacture of Bessemer steel was started at Neuberg in February, 1865, with one immovable Swedish converter and one revolving English converter of about 60 cwt. capacity each. It was intended from the start to use exclusively Neuberg pig-iron, and to run it from the blast-furnace into the converter without remelting.

The results obtained in the year 1865, have partly been published before this. The above tables contain the working results, beginning from 1866, since when the manufacture may be considered as being carried out regularly and steadily.

The Swedish converter was removed in the middle of the year 1866, and replaced by a second English or revolving converter of 80 cwt. capacity. The results obtained in this Swedish converter were quite or near as satisfactory as those obtained in the English vessel as regards the quantity and quality of the products and the consumption of fuel. But the amount and cost of tuyeres, bricks, and other lining materials required for the Swedish converter, were very high.

Table III, shows a very great consumption of cokes for heating the converters in the second half of the year 1866. The reason is that about this time the opinion prevailed that the heating of the converter to a high temperature, before the beginning of the charge, might be of great importance, and the experiment was made to see the effect. [It may, indeed, be seen from Table II, that during the same time the scrap produced by discharges from the vessel was considerably diminished.] In the beginning of the year 1868, the production had to be increased, and as the blast furnace was not able to furnish the required quantity of pig-iron, an additional number of charges were made with pig-iron remelted in a cupola furnace. Thus several charges could be blown in immediate succession, which circumstance lessened the consumption of heating fuel to a great extent. [The production of scrap was diminished at the same time.]

From 1866 to 1868, the steam for the Bessemer blast-engine was taken from the same boilers which furnished the steam to the blast-engines of the blast-furnaces.—These boilers being heated by the waste gases from the blast-furnaces, it was only necessary to burn some wood, in addition to the gases, to fully produce the quantity of steam required for the Bessemer engine.—Towards the end of 1868 separate boilers were put up, and were heated with bad and cheap fuel as lignite, cinders and small coal.

The increase in the consumption of lining materials, in 1869, is due to the use of a less good, but cheaper quartz. More fire-bricks were used in the last twelve months, because the cast-iron bottom plates below the moulds were replaced by frames lined with fire-brick. S.

GOVERNMENT AID TO SCIENCE.

From "The Engineer."

Two or three years ago several thousands of pounds per annum were placed by the late Government at the disposal of the Royal Society, to be expended in the establishment of meteorological observatories in different parts of the United Kingdom, in order to supply accurate daily weather reports to the Board of Trade. This step was not without its moral influence upon the scientific world, for at the British Association at Norwich last year, it was suddenly discovered that the scientific world generally was very badly off, and most decidedly in want of money aid from the Government. Lieutenant-Colonel Strange read a paper at Norwich on the subject. He acknowledged that Government aid would be certain to give rise to "jobbing" and jealousies, but urged that the good done would outweigh the evil. The opposite side of the question was then taken up by Professor Huxley, who said, with much reason, that the present free and easy way of pushing on scientific research was the best for the nation and best for philosophers. Nothing would so chill and deaden the energies of the scientific world as the transformation of any large portion of it into a Government department. The result of the conference at Norwich was the appointment of a committee of eminent philosophers to inquire whether adequate means exist for the vigorous prosecution of scientific research; and if not, what remedy should be provided.

So far everything went on swimmingly, but then a frost, a chilling frost, blighted the bright dreams of the philosophers. A new Chancellor of the Exchequer came into power, who has said "No!" many times and oft, to demands made by individuals and corporations for aid from the national coffers. He not only refused a modest demand for cash made by a Scotch scientific society, but expressed doubts whether the grant made for meteorological observations under the

Board of Trade ought to have been made.—The Government, he stated, ought to do nothing which the people are likely to do for themselves if left free to act. With the prospect looming in the future of facing a gentleman of this description, the Britith Association Committee, of course, could not very well come to the conclusion that application should be made for a Government grant, which every body a year ago thought would be the result of their deliberations.—But they have unanimously decided that scientific bodies want more funds; and what corporation of human beings does not? A direct onslaught on the nationl resources a being manifestly injudicious, they then recommended that application should be made for the appointment of a royal commission to inquire into the subject. Lieutenant-Colonel Strange read this report of the committee a few days ago at the Exeter meeting of the British Association, and he prefaced it with a doleful introduction of his own, read with the countenance of a mute at a funeral.

Many will doubtless think that a scientific journal is bound to support scientific men in all and every rush at the public purse.—Apart from the selfishness of such a line of action, and its neglect of the general interests of the nation, in this case it is no use doing so. Very recently an application of a very influential character was made to the Chancellor of the Exchequer to appoint a royal commission to inquire into the working of the Bank Charter act of 1844. This act is believed by the political economists to be the source of many commercial panics and of a vast amount of pauperism, while any banker can bear witness that it has indirectly been cause of the ruin and bankruptcy of many honestly managed banks.—Yet this application, of more importance than the one proposed to be made by the British Association, was refused on the ground of the expense of the commission, and because the action of the law upon the public is perfectly understood already by those educated in the science of political economy. Of course, once let the proposed commission on scientific needs be appointed, the result of the large amount of talk which would follow would not certainly be a recommendation of increased national expenditure. Instead of trying to obtain a few thousands of pounds annually in this way, with the certainty of failure, why do not the committee take steps to get a few tens of thousands of pounds annually from a more legitimate source? The subject of national education must soon come to the surface, and if the British Association then urged the necessity for general teaching of elementary science in schools, and the desirability of making grants to encourage this branch of education, all the members of the British Association would support the movement.—At present there is a division in the camp, and very many hold the views of Professor Huxley. If science were generally taught in schools we should soon have a population willing to subscribe largely to push on scientific research without aid from the Government. The Wesleyans have shown what enormous sums can be raised annually by private subscriptions, where large numbers of people join together in favor of any particular line of action. Those numbers may or may not be one in twenty of the total population, but is it hopeless to attempt to train up a similarly large number of people to have an interest in science? If the British Association and its president of next year were to make a dead set at the Government, insisting that the teaching of science in schools shall be a marked feature in all future educational legislation, they will succeed to a large extent, for they would carry national opinion with them. The present plan will fail, and even the intention mentioned by the President of section A, of getting up a discussion upon it before the settings of the British Association came to a close at Exeter, was abandoned.

THE SEWAGE OF TOWNS.

Abstract of a paper by Dr. BENJAMIN H. PAUL, read before the British Association.

This paper was the voluminous and valuable report of a committee on the Treatment and Utilization of Sewage. The report traced the history of sewage in England from the most primitive appliances, to the use of cess-pits, and lastly, of the present water carriage system. At the outset of the adoption of this system, it was contemplated to utilize it as manure, but was not enforced, and was now generally carried into the rivers and the sea so long as it did not create a great nuisance. The system now greatly polluted the rivers, and had become an evil of national importance. During the last thirteen years the subject had engaged the attention of three Royal Commissions. with a view to finding remedial measures, The object of this committee was to supplement the efforts of the last sanitary commission, by obtaining special information of local influences of the experience of various towns. Town sewage, as now known, was a source of nuisances and inconvenience, and was undoubtedly injurious to health, and it became a very serious matter to determine what to do with it. The committee had obtained information of the sewage on the Continent and Austria. From this they gathered that both in large towns and country places there the old system of cess-pits was still in use, and water closets were rare even in large towns. In Berlin, with its population of more than 600,000 the still more primitive and objectionable night-stools were employed, 50,000 being in use every day. This was remarkable in a country so advanced in other respects as Prussia is. Hamburg was the only continental town in which water carriage system was carried out. In other places large portable reservoirs were used, and were periodically removed outside and there emptied. In some cases the householders pay for the removal, in others it is sold to cover the cost. In Antwerp the profits of the sale is two or three thousand pounds, and in Strasbourg the sale just covers the cost. The result of this foreign information was to show that the removal of sewage so as to prevent evil consequences, was at least as much an open question as in this country, and that there was an opinion that the collection of refuse materials was injurious to health, by exhalations, and by polluting rivers and wells, and that a remedy is required. The great question was to decide as to the best mode of dealing with the town refuse so that it might be satisfactory to health and would realize its greatest agricultural value as manure without its concurrent advantages. A series of questions had been sent to 338 towns in England, and answers had been received from 107 towns, of which 11 had no sewage at all, and in others the systems adopted were very defective; 48 towns had a complete water carriage system, and 15 applied the sewage to land, previously subjecting it to treatment. The results varied considerably, the local influences at work being very different. From some towns it was said that all obnoxious matters were removed from the sewage, and that it flowed off clear as water. It was questioned, however, by chemists, whether all deleterious matters were destroyed, and whether the clarification as seen by the eye was not all the advantage gained. This sewage manure was sold from 6d. to 2s. 6d. a ton, and one town mixing it with other substances, made a manure sold for 7s. 6d. a ton. Leicester sold 5,000 tons a year. The result of this utilization of sewage had been seen in the improved condition of the streams of rivers. Little objection had been urged against the use of sewage for irrigation of land, and where objections were made they were not supported by medical authorities. The cost of these various systems, and their influences on the sanitary state of the towns, were subjects for further inquiry. The ventilation of sewers was also an important question, for in them gases were given off and found to escape through the drains of the streets and of the houses. Such questions as the value of the sewage for agricultural purposes, and the best means of collecting and preparing the manure, required further consideration, and for this purpose it was suggested that the committee should be continued.

CAISSONS.—At Rochester, England, a bridge across the Medway was commenced in 1850. The piers were made of cast-iron caissons, 7 ft. in diameter, and driven a depth of 44 ft. into the bed of the river, through gravel, sand, rocks, and the debris of an old timber bridge, built, probably, by the Romans. At first the exhaustive process was used, but was soon found to be insufficient, and the atmospheric pressure process was tried. The caissons were then driven in an unexpectedly short space of time, and at one-third the estimated cost, through the obstacles above mentioned, and that to the great surprise of all engineers. However this was not the first experiment of the kind; it had been successfully applied several years previously in France, in sinking iron caissons through quicksands, in order to reach a coal mine at a depth of 82 ft. beneath the surface, the workmen having been exposed to a pressure of three atmospheres.

In several other works the vacuum process was first tried, but soon abandoned as insufficient. They were as follows: In the year 1851, the engineer of the Rochester bridge, W. Corbitt, built the piers of the Peterboro' bridge with cast-iron caissons 6 ft. square, placed in contact and afterwards filled with masonry. In the year 1853, Major Gwynne and L. Fleming built the foundations of a bridge across the Pedee, North Carolina, with columns 6 ft. in diameter, driven a distance of 25 ft. through sand. Afterwards, they constructed the Santee bridge. In the year 1859, General Smith built the Savannah bridge. In 1860, the Third avenue bridge across the Harlem river was commenced. Brunel built a pier at Saltash with a caisson 37 ft. in diameter, sunk to a depth of 98 ft. below the water; it had the size and shape of the foundation of the entire pier, and was afterwards filled with masonry. All this was accomplished by means of atmospheric compression, and this system has, since the year 1850, met with more favor the better it has become known, until now it has become almost the universal method employed where currents are rapid and the river bed treacherous. The American experience is this, to wit: That in the Southern rivers, where cypress logs and other large objects are encountered, their removal by the exhaust system is utterly impossible, but, on the contrary, comparatively easy by means of the compressed air process which, therefore, is now exclusively used. Also, the most eminent engineers in England agree as to the utter insufficiency of the exhaust and the advantage of the plenum process. We will only mention Corbitt, Hawkshaw, Simpson, Brunel, Hemans, Brunlees, Page, Fox, Rawinson, Brereton, Fitzgibbon, Brassy, besides many continental engineers.

A caisson in which the air is driven down by means of pressure, notwithstanding it is worked on the principle of the diving-bell, is very distinct from it; because a diving-bell is a mere tool suspended from a vessel or from the shore, and used to lay foundations, etc., while the caisson forms a part of the foundation itself. The diving-bell is hoisted out, and when at the bottom is inaccessible, while in case of the caisson there is an uninterrupted communication with the outside. Our Harlem bridge contains also that improvement, which the builder, Wm. McAlpine, has termed "expansion of the base." The supporting power of the column is thereby greatly increased at a trifling cost. We will not confine ourselves to a description and illustration of English and Danish engineering works, overlooking the merits of our American engineers, whose achievements are equal in merit to those abroad. It is, however, unfortunate that they are too busy to give attention to descriptions for the benefit of the public. We will, in a following number, give a description of the process carried out in the construction of the Third avenue bridge. It is a very fine specimen of hydraulic engineering, though we cannot deny that it has two grave defects. It cost too much money, and was too long a time under way. In justice to the engineer we must, however, say that these were the faults of the political gentlemen then to be found over the way, in the City Hall, who had charge of the disbursement of the money required for its construction.—*Engineering and Mining Journal.*

PENETRATING INCLINED ARMOR.

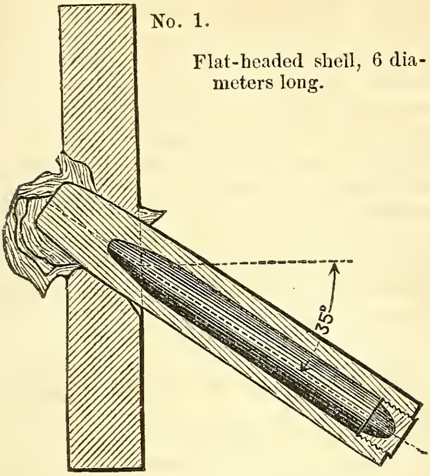
From a paper read before the British Association by JOSEPH WHITWORTH, Esq., "On the Penetration of Armor Plates with long shells of large capacity, fired obliquely."

At the meeting of the British Association at Norwich, last year, I contributed a paper to this section on "The Proper Form of Projectiles for Penetrating through Water." This paper was illustrated by diagrams showing the effect produced on an iron plate immersed in a tank of water, by projectiles with flat, hemispherical and pointed heads. Copies of those diagrams are now before you. In that paper I claimed for the flat-pointed form of projectile, made of any metal, three points of superiority over the spiral-pointed projectiles adopted in the service: (1) its power of penetrating armor plates, even when striking at extreme angles; (2) its large internal capacity for bursting charges when constructed as a shell; (3) its capability of passing undeflected through water, and of penetrating iron armor below the water-line. This latter feature was, I think, satisfactory proved by the experiments described last year, and I desire to draw the attention of the section to the experiments I have made for illustrating the penetrative power of long projectiles with the flat front, fired at extreme angles against iron plates.

These experiments are illustrated by the projectiles actually fired, and the plates they penetrate, which are laid on the table, and also by the diagrams before you.

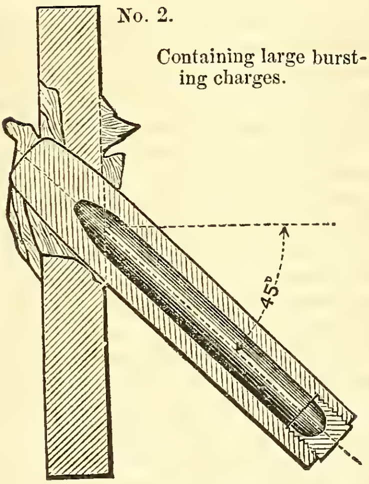
The gun from which the projectiles were fired is called a 3-pounder, though capable of firing much heavier projectiles. It weighs 315 lbs., and the maximum diameter of its bore is 1.85 in.

The charge of powder used, in all cases,



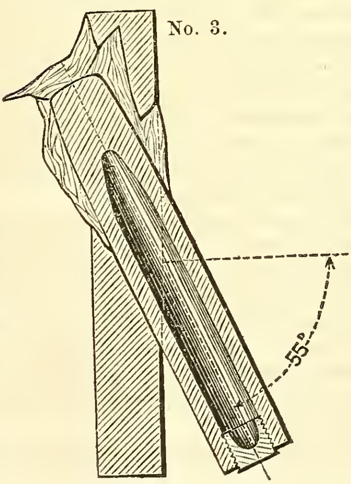
No. 1.

Flat-headed shell, 6 diameters long.

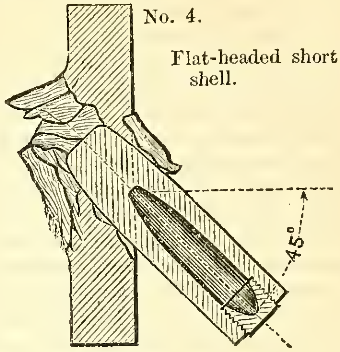


No. 2.

Containing large bursting charges.

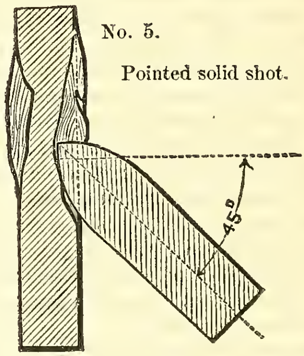


No. 3.



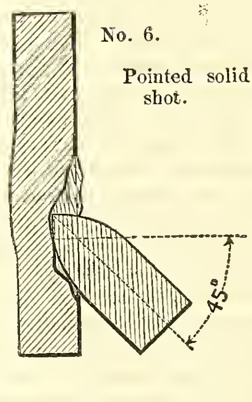
No. 4.

Flat-headed short shell.



No. 5.

Pointed solid shot.



No. 6.

Pointed solid shot.

was 10 oz., and the weight of the 6-diameter projectiles is 6 lbs.

No. 1 is a portion of a plate 2 in. thick, penetrated by the 6-diameter flat-fronted projectile also; No. 1 at an angle of 35 deg. No. 2 is a similar piece of plate, 1.7 in. thick, completely traversed at an angle of 45 deg. by the flat-fronted projectile No. 2, which buried itself to a depth of 30 in. in a backing of iron borings. No. 3 is a piece of plate 1.75 in. thick, penetrated at an angle of 65 deg. by the flat-fronted projectile No. 3. No. 4 is a plate 1.7 in. thick, nearly penetrated, at an angle of 45 deg., by the $3\frac{1}{2}$-diameter flat-fronted projectile No. 4. No. 5 is a plate $1\frac{1}{2}$ in. thick, against which the ogival-pointed projectile No. 5 was fired at an angle of 45 deg.; the projectile failed to penetrate the plate, being defected in consequence of the pointed form of the head. The distortion of its shape shows the force with which it struck the plate, and proves the good quality of the material which could resist such a test. No. 6 is a plate also $1\frac{1}{2}$ in. thick, against which an ogival-pointed projectile, of the service proportions, viz: $2\frac{1}{4}$ diameters long, made of Pontypool white iron, has been fired; the projectile has scooped out a furrow 4 in. long and $\frac{7}{10}$ in. deep; it broke up into fragments, of which 48 were recovered.

The plates Nos. 1 and 3 were purposely thicker than the projectile could quite pass through, in order that the "work" of the projectiles might be as severe as possible; an examination of the projectiles themselves will show how well they have stood the severe strain to which they have been subjected. The data thus obtained fully establish, I think, the superiority I claimed for the flat-fronted projectiles made of my metal, and satisfactorily prove—(1) that the flat-fronted form is capable of piercing armor-plates at extreme angles; (2) that the quality of the material of the shells enables their length to be increased without any risk of their breaking up on impact, and materially augments their bursting charge as shells; (3) that this increase in length, while adding to the efficiency of the projectile as a shell, in no way diminishes, but, on the contrary, proportionally improves its penetrative power; (4) that the amount of rotation I have adopted in my system of rifling is sufficient to insure the long projectiles striking "end on," and, consequently, to accumulate the whole effect of the mass on the reduced area of the flat-front.

These experiments show, further, that the ogival-pointed projectile has but small power of penetration when striking at an angle, solely on account of the form of the head; a projectile of Whitworth's metal, with the like ogival-pointed head, as a service projectile, having resisted the shock of impact without breaking up, but being deflected in precisely the same manner as the pointed service projectile, which was shivered into fragments. The objections I made in my paper last year to the ogival-pointed projectile—(1) that its form of head causes it to glance off from plane or convex surfaces when hitting diagonally; and (2) that the brittleness of its material renders it liable to break up on impact—I have now proved to the section. The facts illustrated by these experiments are not of recent discovery. Ever since 1858 I have constantly been advocating the flat front. I have on the table a small plate $\frac{1}{2}$ in. thick, experimented upon, in 1862, with hardened steel bullets fired from my small bore rifle. No. 39 is the hole made by a flat-fronted bullet, which has penetrated the plate at an angle of 45 deg.; No. 40 is the indent of hemispherical-headed; and No. 41 of an ordinary round-nosed bullet, both fired at the same angle of 45 deg. These three rounds were fired in 1862.

Within the last few days I have had an ogival-pointed shaped bullet fired at the same plate at the same angle, in order to confirm the effect with that produced, on a larger scale, on the plate No. 6. It is interesting to observe how closely the results obtained with the small caliber of my rifle agree with those of the 3-pounder gun which form the subject of this paper. Those experiments recorded in the paper were made with a gun of small caliber, from considerations of economy and convenience; but I have always found that what I could do with the smaller calibers of my system, could be reproduced in the larger sizes; and from my past experience I feel warranted in asserting that tfie effect of penetration now exhibited could be repeated, on a proportionate scale, with my 9 in. guns at Shoeburyness, or with the 11 in. guns my firm are now engaged in constructing.

A glance at the formidable nature of the projectiles thrown by these guns, and a consideration of the effects they may be expected to produce, will show the importance attaching to the question of penetration of plates by long projectiles. The 9 in. guns to which I have referred weigh fifteen tons each, and are capable of firing powder charges of 50 lbs. A 9 in. armor shell, 5 diameters long, weighs 535 lbs., and will contain a bursting charge of 25 lbs.

I have no hesitation in saying that these projectiles would pierce the side of a ship, plated with heavy armor, at a distance of 2,000 yards, and at some depth below the water-line. The 11 in. guns will weigh 27 tons, and will be capable of firing 90 lbs. powder charges. The 11 in. shells, 5 dial meters long, will weigh 965 lbs. and wil contain bursting charges of 45 lbs., and would pierce the side of the ship Hercules, plated with 9 in. armor, at a distance of 2,000 yards.

Were it not that the increased destructiveness of war must tend to shorten its duration, and diminish its frequency—thus saving human life—the invention of such projectiles could hardly be justified; but believing in the really pacific influences of the most powerful means of defense, these long projectiles I call the "anti-war" shell. The principle I have always insisted upon, and laid down for my own guidance in artillery experiments—when either a low trajectory or penetration is required—is, "that every gun should be in strength capable of withstanding the largest charge of powder that can be profitably consumed in its bore." I have drawn up the accompanying table of the sizes of the bores of my guns, with their proportionate powder charges, and the guns will all be fully equal to this duty, and I believe the greatest possible effect from the consumption of a given quantity of powder will be obtained. But the guns adopted in our naval service are not equal to such a test; nor, as I believe, are they so proportioned as to realize the best effect from the quantity of powder they consume.

Four guns of 12 in. bore have lately been put on board the Monarch. They weigh 25 tons each, and charges of 50 lbs. and 67 lbs. have been fired from them with projectiles of 600 lbs. weight. I have no doubt that these guns have been made with all possible care, and are as strong as their material and construction admits; but if the weight of these guns was in proportion to the capacity of their bore, and if the material were the best that our metallurgical skill could supply for such a purpose, they ought to fire 117 lbs. of powder, and projectiles of 1,250 lbs. weight. They would then be efficient weapons; but at present they are more formidable in name than in reality.

We are often flattered by being told that we have the best guns in the world. That may, or may not be the case. But I think that we should not rest contented while we are still so far from having attained as much as our present advancement in mechanical and metallurgical science has rendered possible for us.

Particulars of Ammunition for Whitworth Guns from 5.5 *in. to* 13 *in. bore.*

Caliber of bore.	Powder charge.	Common shells, cast iron, 3.5 diameters long.		Armor shells, Whitworth metal, 5 diameters long.	
		Bursting charge.	Weight of shell.	Bursting charge.	Weight of shell.
in.	lbs.	lbs.	lbs.	lbs.	lbs.
5.5	11.0	4.0	70	6.0	120
7.0	23.0	8.5	150	12.0	255
8.0	34.0	13.0	220	18.0	375
9.0	50.0	18.0	320	25.0	535
10.0	70.0	24.0	440	35.0	740
11 0	90.0	32.0	580	45.0	965
12.0	117.0	40.0	750	58.0	1,250
13.0	150.0	51.0	960	75.0	1,615

Mr. Whitworth's patent cartridge increases the range from 15 to 20 per cent. JOSEPH WHITWORTH & Co.
Manchester, 1869.

GAS FROM SEWAGE—A vague report of some experiments which have been made in India, and which, it is said, have resulted in the production of gas of high illuminating power from sewage, has set numbers of people speculating on the possibility of lighting London from the same source. If this could be accomplished no modern application of science could equal it in importance. It would at once remove a nuisance and convert an enormous waste into profit, and besides that would, in London alone, save the consumption of something like 1,000,000 tons of coal a year. While we are yet in ignorance of the mode of operating which has resulted in the success reported, we can only, with the knowledge we possess, speculate on what may be accomplished by different methods of treatment. Sewage in London, now well drained and well supplied with water, means animal excretia and household refuse largely diluted with water. What sewage means in India we do not know, but, according to Sir John Thwaites, it is solid excretia. Now, the only conceivable mode of obtaining gas from such a material as solid excrement, is by distilling it in a retort just in the same way as we do coal; and, as we know the chemical composition of the excrement, it is not difficult to guess what the result of the distillation would be. It would, in fact, be a disgustingly offensive mixture, consisting probably of marsh gas, carbonic oxide, carbonic acid, ammonia, and some other nitrogenized vapors, which would give to the whole an odor to which the smell of burnt feathers would be a perfume. No doubt most of what might be considered impurities in this mixture could be removed, and the two combustibles, marsh gas and carbonic oxide, left alone. But in this case the bulk of the gas would probably be reduced by at least one-half; and the remaining half would have no value for illuminating purposes, while it would be highly poisonous. We may say, however, that although we think it highly improbable that any olefiant gas or light-giving vapor would be produced in the process, it is quite possible that some might be present if any kind of fat were found with the excretia.

So far with the treatment of the solid matters. We may consider now how gas may be obtained from sewage diluted with a small quantity of water. Placed in close vessels and allowed to ferment, the result would be the slow production of large quantities of marsh gas, carbonic acid, ammonia, and a few other gases; but, again, the gas would give no light when burnt. If lime were added to the slush, marsh gas would be obtained more rapidly, and in larger quantities, and no carbonic acid would be mixed with it. If we take sewage such as we have in London, and allow it to ferment, we again procure marsh gas; but neither in this case nor with the slush do we procure gas possessing any illuminating power. We are quite willing to confess our ignorance of any feasible means of obtaining gas from sewage but those we have mentioned above. We shall probably be laughed at by those no better informed than ourselves. Meanwhile, we shall wait for an exact account of the experiments made in India, in the expectation of learning that something more than sewage has been employed. In dismissing the matter until we get the information, it may be worth while to notice what changes the manufacture of gas from sewage in London would necessitate. In the first case we put the use of solid excretia; it would involve the entire discontinuance of our present system of house drainage, and a return to cesspools, or some equivalent for them. If concentrated sewage be used, it means a double system of drainage for every house and the whole metropolis. Lastly, if ordinary sewage be used, it has been calculated, from the results of Dr. Letheby, who analyzed the gases produced in the fermentation, that to procure the gas required for one day and night in winter it would be necessary to store, in close vessels, twelve hundred millions of gallons, or more than a fortnight's sewage, which is nearly double the quantity that all the reservoirs of all the London water companies put together would contain.

Some other considerations present themselves, which we may dismiss very briefly. In the fermentation of sewage there is no doubt that various morbid poisons are developed. The poison of fever is generally believed to be derived from this very source, and, according to some, cholera is spread by the same means. A leak in a gas-pipe might, therefore, involve worse consequences to a household than result from untrapped trains. But on this matter it is needless to speculate. We say again we wait for information.—*Mechanics' Magazine.*

SURVEYING INSTRUMENTS.

By E. Sherman Gould, C. E.

NO. I.—THE SIXTY-SIX FEET CHAIN.

The ordinary chain used in surveying is very susceptible of, and very much exposed to, both extension and contraction.

1st. It expands and contracts by heat and cold. Its expansion between the freezing and boiling points is the $\frac{1}{1000}$th part of its length, or nearly $\frac{8}{10}$th of an inch. This source of error is of course neglected in ordinary operations.

2d. It stretches very much by being tightly drawn when in use, and is shortened by the links becoming bent. This must be guarded against by frequent comparisons with an accurate standard.

If the ground to be chained were perfectly level and smooth, a very high degree of accuracy could be obtained even with the ordinary chain. But in practice it is never so. The ground is always more or less rough and undulating, and these obstructions and deviations take up a portion of the chain, and make the measurements too long. The skill in chaining consists in knowing at a glance the amount of allowance to be made from the nature of the ground chained. I should recommend in all cases that the most experienced hand should go ahead.

This is contrary to rule, but I am convinced that it secures the best chaining. The follower has only to hold firm to the pin, and keep the leader in line, while the latter must estimate the amount of chain taken up by obstacles, etc., and make the necessary allowance.

On sloping ground (which should always be chained *down hill*, even if it is necessary to chain the slope backwards) the chain must still be held horizontal. In order to do this, it is necessary, sometimes, to chain in short lengths. The late Prof. Gillespie, in his admirable treatise on surveying, gives the following excellent method of handling the chain in such cases, in the following words: "To measure down a steep hill, stretch the whole chain in line. Hold the upper end fast on the ground. Raise up the 20 or 30 link mark, so that that portion of the chain is level. Drop a plumb line or pin. Then let the follower come forward and hold down that link on this spot, and the leader hold up another short portion as before." In this way the liability to error in adding up the short measurements is avoided.

When the whole chain is held up off the ground, the catenary curve that it forms will reduce the length at least an inch, if a good stretching pull be not exercised.

Under the guidance of an experienced leader, the measurement of 30 or 40 chains, if repeated, should not show a variation of more than a link, if the ground be at all favorable. This degree of accuracy should be insisted upon in important work. Greater accuracy cannot be obtained by the ordinary process.

NO. II.—THE COMPASS.

This instrument was formerly used for even the largest and most important surveys, but is now falling into almost entire disuse, except as in the form of a pocket instrument, and for some purposes which will shortly be mentioned. With it accuracy is unattainable, except through accident. The only reason why its imperfections are not more apparent is, that as the observations, unlike those taken by the transit, are independent of each other, their errors, by the doctrine of chances, are apt to neutralize each other to a certain extent. Were it otherwise, the results would be too grossly inaccurate to permit of the use of this instrument in any case.

The great vices of the compass as an instrument of precision are,

1st. Its susceptibility to local attraction.

2d. The diurnal variation of the magnetic meridian, which amounts sometimes to as much as a quarter degree between the morning and the afternoon of the same day.

3d. The impossibility of reading the instrument with exactness, owing (*a*) to the bluntness of the indicator, or needle; (*b*) to the fact that this indicator does not come in actual contact with the graduated limb; (*c*) to its unsteadiness; (*d*) to the insufficient minuteness of the graduation of the limb, it being necessary to estimate the number of minutes, less than 30, cut by the needle.

4th. The imperfect manner in which the instrument is usually adjusted, it being very rare that two compasses will agree in the bearing of the same line.

It must be borne in mind that I am now speaking of this instrument in reference to the higher operations of surveying, where a considerable degree of accuracy is required. For ordinary purposes, such as "running around" a small farm, particularly with a view to ascertain its acreage, the compass is undoubtedly the handiest instrument that can be employed in point of rapidity in the field, and the convenient shape in which the notes are taken for office computation. For all kinds of rough and preliminary work, too, where it is desired to obtain, with but little outlay of time, an approximate estimate of the "lay" and extent of a tract of land, and for reconnoitering, it stands without a rival, for by its aid a line can be run through the woods without felling any of the trees which intercept the view, and no back sight nor base are necessary, beyond those which the magnetic meridian itself furnishes. In a word, it admits of *superficial work* in association with a sufficient degree of accuracy for approximate purposes, which instruments, like the transit and theodolite, do not. It is, when it becomes necessary to lay out or survey with accuracy a large body of land; to range long lines and turn angles, that the compass proves itself a worthless auxiliary, and loses signally its great advantage of rapidity, for the work, where checking at first has to be tediously wrought into shape by successive approximations, the first locations being merely trial lines, from which the true ones must be deduced—a work of some difficulty, since lines run with the compass can never be quite straight.

In using the compass abundant time should be given for the needle to settle. It should be borne in mind also, that the center of the compass, unlike the transit, is not necessarily directly over a certain point when a plumb line, suspended under the tripod head drops upon it, for the ball and socket of the compass is so high above the tripod head, that the centre of the instrument may be carried considerably to one side or another of the given point. In ordinary compass work, however, this is a matter of little consequence.

In running out lines with a certain bearing, the vernier may be advantageously used. Thus, to locate N. 12° 23′ E., set the vernier 23′ to the left, *i. e.*, as if for westerly variation, and run N. 12° E. by the needle.

In taking the bearing of a certain given line, the manipulation of the vernier is so tedious, that its use is generally abandoned by surveyors.

SUB-AQUATIC TUNNELS.

From "The Builder."

The anticipated success of a well-designed, though cheap and simple, tabular driftway under the bed of the Thames, has attracted a considerable share of public attention to the subject of subterranean, or subaquatic, communication. The idea of a tunnel, indeed, has been rendered so familiar to the inhabitants and to the visitors of London by the convenient service of the Metropolitan Railway, that persons who are devoid of the slightest idea of the difficulties with which the engineer has to contend, from the moment when he bids farewell to open daylight, come to speak of a tunnel as a very ordinary piece of work, and gravely discuss the feasibility of a structure of this nature, of the modest length of 30 miles, and at a level dipping some hundreds of feet beneath the bottom of the Straits of Dover.

Mr. Barlow's success, we trust, is now beyond doubt. Of the 1,320 feet demanded for his driftway, he has already safely constructed upwards of 1,000 feet; and the tube, advancing from a shaft on the northern bank of the Thames, has been pushed beyond low-water mark on the opposite shore. In his letter published a few days since, Mr. Barlow asserts that the very moderate estimate of 16,000 pounds for the entire work will not be exceeded. Should this prove to be actually the case, there can be little doubt of further demand on the skill of so economical an engineer. But the reason for which it occurs to us that it is most important that the public should not be misinformed as to the actual risks and difficulties against which the engineer of a tunnel has to provide, is as follows:

In all normal times of engineering activity, a marked and novel success, especially if it be a financial success, is apt to force a heavy aftercrop of more or less similar schemes. In these cases it too often follows that the modest anxiety and patient forethought which have led to the first triumph are altogether discarded by those who rush to follow in the same path. B. has tunneled under the Thames; therefore C and D will fight for authority to tunnel under the Mersey, and E and F to tunnel under the Channel. Talk of the latter project as wild, and its supporters will point with triumph to the little *adit* by the Tower.

Tunneling, indeed, is not an invention of the present day, nor of the present century. That great engineering people, to the influence of whose institutions we owe so much of the very framework of modern civilization, wrought tunnels which endure to the present day. Two thousand two hundred and sixty-four years ago, the miners of Furius Camillus drove the famous *Emissarium* through a part of Mount Alba, and tapped the swelling waters of the lake of that name. Etruscan science, on this occasion, directed Roman energy. But the *tufa* of Italy, a material which behaves under the pick of the miner in a mode very similar to the English chalk, is bored and drilled with shafts, and *adits*, and lofty tunnels, in all directions. The gallery of Posilippo is familiar to every visitor of Naples. The curious system of galleries and caverns known by the name of the Grotto of the Sibyl, dates from a remote antiquity. Whether it were from an observance of hydraulic laws, from want of a trustworthy material for pipes, or from the conviction that the steady unchecked action caused by gravitation was best suited for the permanence and purity of a water-supply, we need not now pause to inquire. But certainly a knowledge of the engineering works of ancient Italy might have taught the English predecessors of Brunel more than they ever knew about tunneling.

The school for tunneling in England has been, of course, underground. In our mines, especially in our coal mines, the problem of constructing subterranean galleries has long been solved. In certain districts, such, for instance, as that of the Peak, in Derbyshire, vast natural caverns open out in the living rock, glittering, when lighted up by the miner's torch, with sparkling stalactites, accessible, in places, only by narrow and low-roofed passages; and at times traversed, or occupied, by rivers, which long borrow from the light of day. In one Derbyshire cavern a river precipitates itself down an unfathomable abyss, and what becomes of the water is unknown.

But with all our practices as to mining, and all our acquaintance with natural subterranean galleries, the progress of the tunnel engineer was slow in this country, until the exigencies of the line selected by Stephenson for the London and Birmingham Railway led to the simultaneous construction of four wide and lofty tunnels, of dimensions before rarely attempted. It is true that the method of piercing the barrier that divided valley from valley had been pointed out, no less than the main directions of the best line of communication had been indicated, by Telford. The Grand Junction Canal was the pioneer and guide of the London and Birmingham Railway. But the canal tunnels were reduced to the minimum cross section. They admitted a canal boat, with the depth of water requisite to float it, and no more. In the earlier tunnels the boats were propelled—or, we might say, coaxed through—by the barbarous and painful expedient of the boatman's lying on his back and pressing his feet alternately against the roof of the tunnel.

In the case of the Thames and Medway Canal, a tunnel of larger dimensions was cut, through the chalk, at Rochester. A narrow tow-path was formed, in this instance, by the side of the water-way. In that tunnel, of some 2,000 yards long, the chalk in some places gave way, and lofty caverns diversified the usual elliptic section of the arch, which in only a few places, was protected by brickwork. When the Gravesend and Rochester Railway was laid through this tunnel, the Government Inspector, Lieut.-Gen. Sir C. Pasley, satisfied himself of the solidity of the chalk roof by the military expedient of *firing at it from a mortar.* He only used, however, wooden plugs.

The Kilsby tunnel was the scene of a most protracted, and for a long time a precarious, struggle of Robert Stephenson, with the great enemy of the tunnel miner—water.—So long and so continuous was the influx, and so far were the methods at first employed from being adequate to keep it under, that the abandonment of the work was at one time all but resolved upon. A quicksand full of water had been tapped by the tunnel, and till this was emptied, satisfactory progress was impossible. Notwithstanding the increased command of steam and of mechanical power which the last thirty-five years have placed at the command of the engineer, the experienced man will yet even now look grave at the prospect of tunneling through a hill that is likely to be wet, unless he can allow of the tapping of the springs, and the *bleeding* of the internal lake, by gravitation.

In this contest with the water at Kilsby, Robert Stephenson could indeed avail himself to some extent of the experience gained by Sir Mark Brunel and his assistants in their long struggle with the Thames. But the Thames Tunnel was unlike any other work. It was long considered, deservedly, and is still ranked by foreigners, as one of the wonders of the world. Skill, patience, energy, enough to have reared a monument of the loftiest dimensions, were buried in that horrible mine. Engineer after engineer was knocked up by labor, by damp, and by the ill effects of the deposit of the London sewage in the bed of the river. But the Thames Tunnel was a work *per se*,—a marine, or rather river, work, under most unfavorable circumstances, rather than a tunnel proper. The normal idea of the latter work is that of boring through the earth. The material may vary; props, and struts, and polling boards may be more or less constantly required; water may pour in, and necessitate constant pumping; but these are the accidents of the case (and very unpleasant accidents they are). They are not essential or constant obstacles to the boring through of a rocky or chalky barrier. Earth, or rock, is the natural bed of the ordinary tunnel. But Sir Mark drove through shifting mud. The square platform which grew together, brick by brick, as his many-partitioned shield was driven forward, was often within but a few feet of the bed of the Thames. It is even probable that, had the problem been affronted in the first instance, the engineer would rather have preferred to construct a double brick arch, working from one end, through nothing but water, than to deal with the ever-varying difficulties of mud, and silt, and clay, and wholesale inpour of the tide.

Indeed, Mr. Barlow claims for his well-considered and simple shield, the merit that it would be so adjusted as to drive a tube ahead through water. It is far from being impossible that such a procedure should be carried out.

In the case, however, of the actual subway, the chief point to note is, that a wise provision has been exercised in fixing the level of the work so deep in the London clay that not a drop of water has entered the drift-way. That necessary for the purposes of the work has been send down the shaft. In fact, though no engineer would have felt justified in making the experiment, there is little doubt that the simple expedient of mining through the clay at the same level, "polling" the drift-way, and following the miners by a gang of bricklayers, who should have turned a brick and a half ring round the aperture, would have met with uninterrupted success. The one thing necessary in a case where, as in this instance, no faults occurred in the clay, would have been to keep up such a rapid rate of progress that the arch should always have been keyed in before the clay began to "creep." How certain, and how formidable, that creeping action is, Mr. Stephenson had ample proof in the Primrose-hill Tunnel. Under the influence of the successful experience of the Watford Tunnel, driven for the most part through solid chalk, the originally designed invert of the Primrose-hill Tunnel was countermanded. But the clay betook itself to fill up the hole drilled through its bowels; and the invert had to be put in, in very much of a scramble after all.

Men familiar with this description of work looked with a sort of amused surprise at the rose-colored statements which from time to time appear in the public journals as to a "Channel Tunnel." They do not say that such a work is impossible. They do not even care to form a distinct opinion on that head. But they are very well contented with the applicability of the proverb, "*Le jeu ne vaut pas la chandelle.*"

A better communication with France is no doubt both extremely desirable and perfectly feasible. Our present mode of transit, obnoxious as it is to the majority of ourselves, islanders as we are, and still more miserably and terrifically obnoxious (to judge from their countenances on deck) to most of our Continental neighbors, is hardly up to the requirements of the day. A safe, speedy, regular transit, free from doubt, from risk, and, above all, free from the fear of that horrible *mal de mer*, is what the English public have the right to expect of the profession of civil engineers, and what that profession will place at the command of the public, on the one sole necessary condition of being furnished with funds. These funds must be large, for the waves of the Channel are rough and tempestuous. But to speak of the sum requisite as one which would be adequate to the construction of a sub-marine tunnel, 30 miles long and 250 feet (some say yards) below the level of the *Manche*, is, to our mind, nothing better than grave trifling with an important practical subject.

It is curious to see how the non-professional imagination has not only run to flower, but to seed, about this question of crossing the Channel. The most remarkable feature in the case, moreover, is, that hardly any scheme is so absurd as not to find solemn-visaged propounders and open-mouthed admirers. It is evident that the material on which Law counted as the basis of his imaginary wealth is still to be found in rich abundance within our shores. It is only necessary to dig. *Les badauds ne passeront jamais.* Neither railway kings, with their royal mode of making things pleasant, nor colossal contractors, with their lines to develop traffic; nor financial companies, with their periodical crashes; nor Brighton directors, with their eight millions laid out so as to earn an annual loss, exclusive of the perished and annihilated interest; nor Chatham and Dover magnates, with their discounts of all per cent, have had more than a temporarily enlightening influence. We are told of scientific French evidence in favor of a grand Channel tunnel. By way of making a few preliminary inquiries, the Chancellor of the Exchequer is to be asked for the trifling sum of a couple of millions on account. The French Emperor, it is added, looks favorably on the scheme, and has given a conditional promise of as much more. All right; we rejoice to hear it.—We have only one point on which to insist. Let us get the French Emperor's money down *first*. Then it will be time enough to inquire about our own installment.

It is proposed, as caution is always desirable in engineering matters, that a drift-way should just be run under the Channel in the first instance, to prepare the way for the tunnel. The suggestion is at once economical, prudent and practical. Let us suppose a drift-way to be run, some five feet or six feet high and wide. Is it to be timbered, or arched, or lined with iron? As the meeting from the two ends would be a thing forbidden by the calculus of probabilities, it will have to be worked from one extremity. As we get on—say beyond the twentieth mile, how will the miners be sent in to their daily work?—how supplied with air or materials?—how will the excavated chalk be sent back to land?

Galleries in chalk are infested, as miners are well aware, with choke-damp. What would be the quantity of choke-damp that would exude from 280.000 superficial yards of chalk surface (when the drift-way had advanced *only* twenty miles), and how would it be withdrawn?

Water infiltrates through chalk. A very small head of water will cause infiltration for a considerable distance. Where bands of flint occur they act like layers of sponge. All the wells in Strood, within a considerable distance of the Thames and Medway Canal, were rendered salt by infiltration through the chalk, when the brackish water of the Medway was admitted into the canal; and the company had to pay, and did pay, heavy damages in consequence. What would be the infiltration through the gray chalk due to the pressure of the water of the Channel? What would be the difference between the exudation from the 280,000 yards of surface at high tide and at low tide? How would the water, on its most modest estimate of its rate of infiltration (which by the by, would increase *de die in diem*), be removed? A few of these practical questions must be answered before we can undertake to speak, with any idea of serious investigation, as to the prospects of the Channel Tunnel.

But we are not limited to one scheme.—Their name is legion. One amateur proposes the formation of an embankment across the Channel, the top to be some 30 feet *below* low-water mark. Rails are to be laid on this embankment (which is kept down for the benefit of navigation), and long-legged carriages, of novel structure, are to run backwards and forwards over the submarine railway. We should like to let the laying of the permanent way to the projector.

Another gentleman proposes a floating tabular tunnel. It is to be moored at certain distances by chains. The process of anchoring and straining the chains at the bottom of the Channel would be highly interesting. Supposing—not to make two bites of a cherry—the tube complete, moored and at work. What a grand idea to think that the whole service of the Continent, and the lives of all who happened to be at any time in a structure that recalls the legend of Mahomed's coffin, would be at the mercy of a beggarly gun-boat, or a mischievous torpedo!

In fact, we warn our friends, when called on for subscriptions for a Channel bridge, or tunnel, or hybrid between the two, to button up their pockets, and wait. The limits of the service of the engineer are, no doubt, rather financial than physical. The limits of speculative imagination appear to be equally removed from the barriers of prudence and from those of experience.

Returning for a moment to the Tower subway, we would mention that the work has been carried forward by the advance of a tabular wrought-iron shield, about 8 ft. in diameter, which is so constructed as to form a close bulkhead in case of need. As this shield is pushed forward by screws, the excavators opening out the ground for a few feet in advance, the permanent tube of the subway is fitted into place behind it, being cast in 18-inch lengths, each consisting of four segments; three of which are of equal size, and the fourth is a mere key-plate, 14 in. or 15 in. wide. Length by length these narrow plates are bolted on the face of the tube, being protected, until firmly fixed, by the shield. The introduction of the narrow wedge-piece has proved a great facility in fitting together the segments of the tube.

The internal diameter of the completed tube is 7 feet. A narrow railway will be laid throughout, and the passengers, being lowered down the shaft by a vertical hoist, will be carried through the subway in an omnibus specially constructed for the purpose, propelled partly by gravity and partly by haulage by a stationary engine. A curious feature in the actual construction of the tunnel is the filling up of the small space, excavated outside of the tube, with blue lias grout. A hole is left in each plate, and through this the grout is driven by a large syringe until the aperture is completely full. The mixture dries so rapidly that it is unnecessary to plug up the holes on the removal of the nozzle of the squirt. How far that irresistible oxidation of the iron (by absorption from the grout), of which we have recently seen such a striking instance in the tomb of King Henry VII, will proceed, remains to be seen. It seems almost a penny-wise-and-pound-foolish proceeding not to have enameled, galvanized, or otherwise protected, the inaccessible exterior of the tube from a very formidable danger which there is no means of detecting until it is too late. Mechanically considered, the injection of the grout is admirable. Chemically regarded, we fear that the same cannot be said.

We avail ourselves of the opportunity to call the attention of all managers of tunnels, mines, and similar works, to the immense facility afforded to the work by the use of the electric telegraph. A constant and instantaneous communication is kept up by the wires between the engine-driver and the face of the work. Lowering and raising of materials, and admission of air by the fan-blast, are thus precisely directed by the foreman on the work itself. The sense of confidence that would be inspired in any case of danger by the possession of this mode of communication would be beyond all price.

THE MANUFACTURE OF RAILS.

From a paper by Mr. E. Williams, before the Iron and Steel Institute, and the discussion following.

In this paper Mr. Williams stated that he proposed to give as concisely as he could the opinions he entertained as to rails, and to consider, from the stand-point of a rail-maker, the several kinds of rails in use, the merits and demerits of each, together with the processes of manufacture generally used. The paper said: The rails of to-day are of two distinct kinds—those made from ingots and those built up; and it must be admitted that—questions of cost and possible supply not considered—ingot-made rails are best. We are in the habit of describing the two kinds as steel rails and iron rails—a description obviously incorrect—because the Bessemer rails now making have a percentage of carbon much lower than that of steel proper as we used to know it. Besides, it is, so far as I know, impossible to define when iron ends and steel begins. It will then be as well to call the two divisions ingot rails and piled rails.

For many years makers of iron by the old processes have desired and endeavored to produce ingots or blooms, each from a single puddled-ball, that would roll into rails. This, if it could be done, would, I have no doubt, make rails equal to any ever made; but the difficulties seem insuperable. Puddled-balls of sufficient size have been, and may be obtained; but it appears impossible to produce moderate compactness of the iron without more work upon it than is possible in one operation. I have come to the conclusion, though most unwillingly, that we shall not succeed in producing by puddling, workable, unwelded, solid blooms and, so far as our present knowledge extends, ingots cheap enough to make rails on a considerable scale are only to be obtained by the Bessemer process. Whether or not the Siemens-Martin process can compete, in point of cheapness of production, with the Bessemer process, is as yet unproved, and the question need not arise here. It is sufficient now to know that both can, without doubt, produce ingots that roll into rails without much difficulty, and that such rails, being free from the possibility of lamination, must be more enduring than built-up or piled rails, however carefully made. It is not unlikely that further experience may determine the precise constitution ingots should have to produce the most enduring rails, but at present this is matter of opinion only. The freedom from welds and layers is an enormous advantage, and the use of ingot rails will, I feel sure, go on increasing, though the rate at which they will push piled rails out of existence must, of course, depend on the relative costs.

If the phosphorus difficulty could be got over, and the cheap pigs of the Cleveland district were available for the Bessemer process, there would be so great a reduction of cost that ingot rails would be almost as cheap as piled ones, and the latter must at once give way; but there is not at present any good ground for expecting that such a change is near, and I see no reason to suppose that for some time to come ingot rails will become anything like universally used, because of their price. The removal, in February next, of the bulk of the present Bessemer royalty-charge, will, no doubt, reduce the selling prices of ingot rails; but I am mistaken if, after all, they can be produced so as to be sold within 40s. or 50s. per ton of the average selling price of good piled rails, the life of which, in the ordinary portions of a heavily-worked railway, would be about fifteen years. For the very severely-worked places ingot rails, at almost any moderate extra price, are, of course, best.

Strenuous efforts have been made by nearly all the great iron makers everywhere to produce steel topped rails, which, it was hoped, would be much more lasting than the usual piled iron rails, and less costly than ingot rails. Puddled steel seemed to offer a cheap and good material for this, and after some difficulty to begin with, it was produced of uniform quality. It is, no doubt, a material capable of resisting well the wear and tear of railway stock, but it could scarcely be welded at all, and as it could not be obtained in solid blooms of the rail size, the system failed and has been abandoned, in this country at least, entirely. That Bessemer steel slabs can by great care and skill be so fastened to iron as to make rails that will wear well is proved by the instances of the rails supplied to the Edinburgh and Glasgow Railway and to the Swedish Government. Probably there have been some other instances also, but I do not expect to find such rails coming into general use, because of the difficulty of welding on the steel plate, which is not much, if at all, less than that of the puddled steel before spoken of. It need not be told to this meeting that steel, however mild, will only stand a comparatively low heat, while iron, to weld at all, must have a high one. Giving the steel top a mechanical grip is, no doubt, to make the best job possible, but the channel steel slab has the disadvantage that the horns prevent the escape sideways of the superfluous cinder, which at best interposes too much between the layers to be welded together. This could not fail to produce faulty welding, which the traffic of an English railway, such as the North-Eastern, would certainly bring to light despite the mechanical fastening.

So far as I can see, then, the only choice as to rails lies between those made from ingots and piled ones, and in the uncertainty as to the Siemens-Martin process it may be assumed that the Bessemer process will supply the former. I do not desire to convey any doubt or even opinion as to the practical value of the Siemens-Martin process ; but it is not yet, in England at least, in operation for rail making on more than an experimental scale, and it is therefore uncertain what proportion of the rail ingots of the future it will supply. The present price of ingot rails is about £10 per ton for usual flange sections, and it is, I believe, the fact that this is not remunerative. After February next makers will save most of the royalty for patent right, and it may be assumed that rails will go down say to £9 per ton. While ingot rails are at anything like this price, good piled rails, the average selling price of which is not £6 10s. per ton, and which, under moderate traffic would live on the average 15 years or more, will, I believe, hold their ground and be in demand. I wish to make it clear that my remarks apply only to good iron rails; the very lowest kind is only bought by those who give themselves no concern as to quality, and first cost will in such cases be the only considerations.

It is not unfrequently asserted that, as a rule, the rails (of course all piled rails) of twenty years or so ago were of a more enduring kind than those supplied now, and I think there is some truth in the accusation. It must not, however, be forgotten that the duty imposed on rails now is very much in excess of that they had to bear in the early days of railways ; and that, therefore, mere length of life is not a correct standard by which to measure their quality. As the weight upon the rail increased, engineers and manufacturers simultaneously adopted the use of more fibrous iron as a preventive. Still every now and then a rail would break despite the extra endeavor to prevent it, and notwithstanding the heavy and heavier tests which rails were required to stand. This has gone on for many years until not a few of the specifications framed by engineers, certainly with the view of ensuring excellence of quality, bring about the reverse, because to meet them, rails are made of fibrous, and therefore difficult welding iron, at an increased cost, and less serviceable than those made after a simpler system. Even, after all the additional cost and the diminished value of the tougher rails, there is an occasional breakage (as there is also now and then a breakage of ingot rails), and I am of opinion that it will be so, despite all possible care, and irrespective of price.

We all know that a percentage of piles or ingots heated are, even by the best workmen, so over-heated, at some stage or other, that they fall into pieces, or become torn in the rolls; there are also, no doubt, some which are heated a shade short of this point, and just hold together, but are almost as brittle as porcelain when finished. This occurs while the great bulk of the rails are abundantly strong, and I do not see how any system of testing can detect the unfortunate instances. They cannot under any tolerable supervision be more than a small proportion—under good watching very small—but I am afraid they will always be a proportion, as there is in the case of crucible steel tyres, which cost eight or ten times as much as rails, and which have all possible care and skill devoted to them. Supposing the all but broken rails to be 1 in 100,000, it will be evident that there is small chance of that one being selected for testing, and if it were chosen, it would be found so exceptional that nothing more serious would follow than the testing of a few more rails to prove that it was exceptional.

I do not at all advocate the discontinuance of the system of testing rails—no prudent maker would abolish it even though it were not insisted on, but it is, I am sure, the fact that the excessively heavy falling weights, prescribed frequently, do necessitate the use of iron for rails that welds with difficulty, and, therefore, does not make the best rail for wear. To meet the severe falling tests it is absolutely necessary to use fibrous iron, and not to heat too much—in fact, to make the piles of iron that, do what you will, is very difficult to weld, and then not to give them the amount of heat necessary to make as good a weld as might be. On this subject I have thought and experimented much, during a somewhat long experience, and I am satisfied that a fibrous nature and weldability do not go together, and that only well-puddled, crystalline iron welds easily, and, therefore, with moderate certainty. Given any kind of wrought iron, it welds more easily in its first stage, that of puddled bar, than at any future one; and the effect of roughing it down, that is, of extra piling and rolling, is always to diminish the weldability of the resulting rail piles. Those who make cable bolts, best boiler plates, and other similar iron, know how certainly they are spoiled if they are worked hot—in other words, if they are welding hot. Cable bolts for a chain are not the worse, but the tougher and softer, because the layers of which they are composed are only firmly struck together, and not welded; but in rails welding is the very life itself. As often as opportunity offered, I have carefully examined rails that had borne an unusual amount of work before becoming so worn as to be replaced, and in, I think, every instance they were what we now would call very brittle rails, and had a rough crystalline fracture when broken under a falling weight.

It is, I think, undesirable to use rail piles of great cross sectional area, which are less likely to be heated equally to the centre than were the small piles of a century ago. Rails at present are heavier and longer than formerly, and it would not, I presume, do to go back to piles 6 in. square, or thereabouts; it would, however, I think, be well not to exceed 8 in. by 8 in., which, with blooming and double-heating, might be well welded. The two great rail-producing districts of this country are Wales and the North of England, and each has a system of working different from the other.

These systems have been explained in detail, and with the aid of diagrams, Mr. Williams went on to say "that the Welsh system has the merit of more work on the iron, that is, greater consolidation, than is obtained by the north of England system. This is a doubtful advantage, if it is really, as I believe, that the iron for rails is, as a rule, too much worked, while it has the demerit of having many through welds in the heads of the rails. The north of England system produces hard crystalline heads, with the fewest possible welds, and when the iron of this district is not too much worked, and thus made fibrous, it is of the most weldable kind, though somewhat brittle. Such iron, it seems to me, is likely to produce enduring rails, and I firmly believe that with proper attention, piled rails can, and will, for a long time yet, be made from it, so enduring as to compete successfully with good ingot rails, produced by the Bessemer process." Mr. Williams concluded: "My desire has been to lay before those who make, and those who use rails, the conclusions my experience has produced, as to the causes of the unsatisfactory wearing power of piled rails, and to show how, in my opinion the evil may be abated. The subject is very important to all, and to no class of men more than to those who, like myself, make piled rails. These are now in competition with ingot rails of the Bessemer process, and cannot, I think, possibly continue in demand, unless the greatest care be given to the manufacture, both as regards the iron used and the welding. Welding, I hold to be the one thing needful, and we should never lose sight of it. As I have before said, the chance of obtaining thorough welding would be much increased by not insisting on more toughness and fibre than is absolutely necessary to guard against so much brittleness as would bring about breakages o the rails in work."

Mr. J. T. Smith (Barrow-in-Furness thought there was a point on which Mr. Williams was misinformed, and that was that in a few months (in February) when the Bessemer royalty would be reduced, rails of that character could be had at £9 per ton. So far as he had been able to ascertain, rails had been at very nearly that price for a considerable time, and the majority of the steel rail masters were looking forward to the time when the royalty would be reduced, that they might be able to recoup themselves for the expenditure they had had on their works.

Mr. Walter Williams (Tipton) briefly described the manner in which rails were manufactured on the Continent, especially in Russia. He had seen from a 12 in. pile rail finished at one heat, the head crystalline and the flange fibrous. If they were able with their common puddled iron to make rails that stood the test that our iron stood, there must be really something in the first process. The rails were rolled out at the rate of one a minute—100 revolutions were attained by the rolls—with perfect crystalline top and fibrous bottom. The welding must be perfect, or the defect would evince itself in the crystalline top. The iron was similar in quality and character, and if they were able to do it there, it must be possible to do it here.

Mr. Hopkins (Middlesbrough), as one practically connected with the manufacture of rails, presumed the author, in condemning the system of excessive testing, applied his remarks especially to double-headed rails. If so, he entirely agreed with him. Practically, a lighter test was sufficient to secure a thoroughly good, general wearing rail, and a rail that would stand the traffic of any railway. As regarded the rail with wearing head and flange foot, to make a bearing on the sleeper, a much heavier test could be applied than in the case of double-headed rails; for in the former the fibres were at the foot of the flange of the rail, a crystalline head being still preserved.

Sir William Armstrong need hardly say that, in the manufacture of guns upon the coil system, a perfect welding was of just as much importance as it was in the manufacture of rails; and great attention had been given both at Elswick and at Woolwich, to the devising of a test which should indicate with some degree of certainty the fitness of the iron for the purpose of making a perfect weld. The conclusion arrived at eventually was this (and it was arrived at both in their practice at Elswick and at Woolwich), that in proportion as the iron had a steely character, so in proportion it was unfavorable for welding. The indication of its steely character was obtained in this way—they took a specimen of the iron, heated it to a certain point, and then plunged it into water; if they then found its tensible strength was increased beyond a certain limit, it was rejected as unfavorable for welding. That iron welded most perfectly which underwent no increase of strength in the process of hardening. Almost all iron did receive an accession of strength similar to that observed in steel by the process of plunging when hot into cold water, though to a less degree. He had a little difficulty in reconciling what he had just stated with what Mr. Williams had said in reference to the constant reworking of the iron, unless it did assume something of a steely character, which he had some difficulty in understanding. Then there was another point on which he might speak, though with more diffidence, and that was in regard to the mode of testing rails. The test which was ordinarily practiced of selecting a particular rail—allowing a heavy weight to fall upon it—might be very well for indicating the general character of the material, but it was not at all a proper method of welding out the rails which were defective in manufacture. He did not see why there should be any difficulty in exposing a rail to a moderate test of that kind. It would not be difficult to devise some apparatus by which that should be done without any manual labor at all. If the rails were laid on a moving machine and struck with a certain force which would not endanger a good rail, but which would as certainly break all rails which were inherently bad, the end would be answered.

Mr. I. L. Bell felt that the quality of rails generally had suffered materially from the wish on the part of the buyer to obtain the rail at far below the cost at which it could be produced, and secondly, harm had been inflicted on the manufacturer by the demand for a species of test utterly unnecessary and excessive. They had on the North-Eastern Railway a great number of rails which had worn uniformly down until from absolute wear they had become unserviceable. It became a most interesting question to him to know what was the character of that iron which had been better able to stand the wear and tear of the railway than iron which appeared to be of a much better quality. He subjected it to an analysis, conducted by Mr. Marreco, a very competent person, who discovered not in one instance only, but in many, that the rails were distinguished by the excessive amount of phosphorus they contained; and, in point of fact, was precisely due to that quality, in which, probably, Cleveland stood preminent.

Mr. T. W. Plum (Old Park Ironworks, Shropshire), thought it worth investigation whether a homogeneous rail from the solid bloom might not be made very nearly approaching in durability and quality to some of the steel rails. The days of steel rails were coming very fast upon them, and it might be worth while for the iron rail makers to turn their attention to the subject. As regarded welding he might say that he had had some little experience in working iron for guns at Woolwich, and some time after that he had to start a tyre mill on the coil principle, similar to that adopted in the construction of guns, except that the bars for the welding were flat instead of square as used for guns. He encountered some difficulty in getting the coils to weld properly, and after some little experience he had them made with convex sides; and so superior was the result obtained by the use of convex bars that, having on some occasions had Swedish iron which was difficult to weld made into tyres, the result was perfectly satisfactory. It was desirable to consider whether rails could not be made from solid blooms, instead of piles as hitherto.

SCIENTIFIC *vs.* PRACTICAL SCHOOLS.

From the "New York Times."

Although the subject of education—classical and scientific, practical and polite, popular and technical—has never been more warmly and widely discussed that at present, there are notable differences of opinion and practice regarding the educational requirements of classes, and the most effective methods of instruction. While we rejoice at the maintenance of the classical department in the great free school of this city; while we cannot too highly appreciate, in this greedy and utilitarian age, the polite and scholarly culture of our older universities, it must be admitted that the dissemination of *practical science* is the great problem of the day.

Education is popularly divided into "classical," that is to say, scholastic and polite, and "scientific," by which is meant practical, useful, and adapted to the daily and modern wants of the nineteenth century workers: but it should appear that this classification is incomplete. If we mean by "classic," pure, chaste, refined, then some of the natural sciences, and above all, the higher mathematics, exhaust that definition, though usually classed as scientific; and certainly nothing could be less practical or more imaginative, not to say poetic, than for instance, the mechanical engineering taught in many of our scientific schools.

In as far as education is a disciplinary process for fitting the mind to work, there must be little to choose between Greek and mathematical roots; but in as far as it pretends to unfold the particular and practical arts and sciences by which graduates can earn fame and bread, it must be admitted that the curriculum of our practical schools, especially in mechanical science, is singularly defective. In his address before the mechanical science section of the British Association, Mr. Siemens, the President, gave authoritative expression to this idea by saying that the information conveyed to students by professors lacking themselves practical experience, "tends to engender a dogmatical conceit, which is likely to stand in the way of originality in the adaptation of new means to new ends; on this account I should prefer to see a sound 'fundamental' education, with a sketch only of the technical arts, followed up by professional training, such as can be only obtained in the workshop, the office or the field." Those who are familiar with the real requirements of practical scholarship, will recognize this to be a peculiarly timely and wholesome statement of the case—but it is a pretty severe commentary on our technical schools.

We wish to be particularly understood as not applying these strictures to all branches of scientific culture. The pure mathematics, as made signally practical in navigation and in certain features of construction, are wholly theoretical, and the authority and method of their teaching in our better schools are unexceptionable. So it is with chemistry, in most of its ramifications, although practical metallurgists could wish for more definite instruction, and less general speculation.

The successful teaching of mechanical engineering, however, must be founded upon an intimate knowledge of the practice. In some branches of technical instruction, lectures are well enough illustrated and improved by means of visiting, from time to time, the establishments where the science is reduced to an art. But neither the theorist, nor the careful observer, nor even the amateur mechanic, can teach young men to run a machine-shop, or to build, or even design steam engines, rolling mills and general machinery, for the following reasons:

First—Although the strength of materials, as subjected to different kinds of statical strains, is a matter of text-book information, machinery designed by these lights *alone* always fails. There must be, above and beyond all tables and formulæ, a certain mechanical judgment as to the proportions and relations of parts. A bearing that will carry a certain load in a stationary engine, housed, clean and never overstrained, may be very inadequate to the same nominal service in a rolling mill or in a locomotive, where frictions and strains may be excessive. The circumstances of over stress, exposure, attendance, convenience of repairs, and other accidental conditions may entirely change the designs of machines subjected to nominally the same service. Experience in construction has also established certain principles of departure from general laws of strength. The reduction of friction, and even more notably, the steadiness and balance of parts, requires in many positions an excessive amount of material. On the other hand, especially in the case of the machinery of transportation, experience has shown the importance of reducing weight at the cost of stronger materials and shapes.

Secondly—The principles of economy, not only of material, but of the work put upon it in construction and in maintenance, must be perfectly familiar to the successful mechanical engineer. No matter how well a machine will perform its functions, if the shape of the parts is such that they cannot be cast, or wrought, or finished by the tools at hand, with the least amount of handling or work, or if the parts are so put together that they cannot be easily taken to pieces for repairs, the machine is to that extent defective.

It is, therefore, evident that mechanical engineering cannot be successfully taught by professors whose knowledge of machine shops and foundries has been derived from walking through them with their classes. Nor does it follow, on the other hand, that one must serve an apprenticeship at the vise and the lathe to acquire the principles of mechanical construction. There is, indeed, little or no strictly educational literature in these branches, but of course there will be, and it will be adequate and suitable, as soon as the men, who alone can produce it, are called upon for lectures and text-books. Until then—until instructors are not only scholars, but the personal designers and builders of successful machinery, students in mechanical engineering had better take Mr. Siemens' advice, and simply master the elementary principles of physics, dynamics and mathematics, and then go to work in drawing rooms, foundries and machine shops, even under the embarrassment of but partially utilizing the many hours at the vise and the lathe, which could be more profitably and economically devoted, if one had more practical teachers in our "practical" schools. Let no one be deceived by names, or by proposed courses of study. The steam engine, for instance, is the subject of lectures in some of our colleges, that brings the invention nearly down to the time of Watt. The training of professors in mechanics and engineering that has been commercially productive, as a business, is the test by which the usefulness of their schools may be chiefly determined.

When young men who want to excel in this branch of industry, hear that experts like Fairbairn, Corliss, Whitworth, Sellers, Worthington, Armstrong, Ramsbottom, Allen, and many other of whom these are types, are going to lecture on steam and general machinery, let them go and listen, at any cost. It may be difficult, but it should not be impossible to secure this kind of talent and training for our chairs of mechanical engineering. Few public questions are of more importance than the proper instruction, in this distinctively engineering age, of the young men who are crowding into this profession. The managers of our educational institutions are charged with a grave responsibility, and the various men of means who are contemplating the endowment of schools, can hardly extend their liberality in a more useful and timely direction.

CABLE TOWING on the river Meuse, which we have heretofore described, appears to be an entire success. All the embarrassments of swift current, varying depth, locks and sharp curves, appear to have been overcome. Inasmuch as it would not interfere with horse-towing, nor require any change in the works, and since a State expenditure of only some $500 per mile for cable would be required, we hope that, say, 50 miles will be at once laid on the Erie canal.

THE "DUTY" OF INJECTORS.

From "Engineering."

The question as to the relative economy of injectors and pumps as boiler-feeders has been frequently discussed, but, as a rule, the arguments on both sides have been founded upon data greatly wanting in scientific accuracy. As far as we are aware, scarcely any reliable experiments have been conducted in this country to ascertain the amount of steam actually used by an injector in performing a given amount of work; and we are, therefore, glad to see that, in an appendix to a recent number of his work on "Steam, Air, and Gas Engines," Mr. John Bourne gives the details of a series of experiments lately carried out by him to obtain some definite information on this point. Mr. Bourne's experiments were made with a No. 6 Giffard's injector, which was made to draw water from a tank, and deliver it, past a loaded valve, into another tank standing at a lower level. The valve, which was of the piston kind, was loaded by a spring-balance, so that the pressure upon it could be adjusted, and both tanks were fitted with gauges. Steam was supplied to the injector from a small vertical boiler, the chimney of which was furnished with a damper, so that an uniform pressure of steam could be maintained, while the boiler was also fitted with a graduated gauge, so that the quantity of water evaporated during each experiment could be noted. The temperature of the water supplied to, and delivered by, the injector was also ascertained at numerous frequent intervals.

Mr. Bourne, however, although he gives the full details of his experiments—which are altogether 67 in number—does not show how the heat abstracted from the boiler is utilized, but he merely remarks that: "As, then, these experiments show the quantity of water evaporated from the boiler, under a determinate pressure, and also the quantity of water lifted against a determinate pressure or head, by the volume of steam answering to the quantity of water evaporated, the duty of the instrument, in any experiment, can easily be deduced, *and it will be found to be very low.*" As to this latter deduction, which we have printed in italics, we either agree or disagree with Mr. Bourne, according to the meaning assigned to the term "duty." If the "duty" of an injector is measured merely by the quantity of water delivered by it against a given pressure by the consumption of a given quantity of steam, then undoubtedly the "duty" of the instrument is, as Mr. Bourne states, extremely low. But an injector not only serves the purpose of a pump, but also heats the water delivered by it; and when employed as a boiler-feeder, the only heat which can be fairly said to be absorbed in working the instrument is the difference between that abstracted from the steam passed through it and that imparted to the feed-water. Measured according to this standard, the "duty" of an injector will be found to be very high; indeed, so high that it would require some experiments of a far more precise character than any yet conducted with the instrument to determine the absolute loss. It is, we think, far from being generally recognized how small a proportion of the steam passed through an injector is actually utilized in forcing the water into the boiler; and it may be interesting if we analyze one of Mr. Bourne's experiments, and show the information which they afford on this point.

As our example, we shall take an experiment in which the pressure against which the water was delivered was the same as that at which the steam was supplied, the circumstances being thus those under which the majority of injectors in use work. The details of the experiment are as follows:

Duration of experiment	12 minutes.
Pressure in boiler	30 lbs. per sq. in.
" against which water was delivered	30 " "
Quantity of water evaporated..	5 gallons.
" " drawn from supply tank	90 gallons.
Quantity of water delivered as measured in receiving tank..	100 gallons.
Initial temperature of water ..	52° Fahr.
Mean final temperature of water	117° Fahr.

As the water in the boiler would have a temperature due to that of steam at 30 lbs. pressure, namely, 274.4°; and as water at this temperature weighs 58.17 lbs. per cubic foot, the 5 gallons evaporated would weigh $5 \times .16 \times 58.17 = 46.536$, or, say, 46.5 lbs. Again, the total heat of steam at 30 lbs. pressure is 1,197.6°, and as during the experiment we are considering the steam was condensed into water at a temperature of 117°, each pound of it lost 1,197.6—117 = 1,080.6, or, say, 1,081 units of heat. The total heat abstracted from the steam used during the experiment was thus $1{,}081 \times 46.5 = 50{,}266.5$ units.

On the other hand, the weight of water

at a temperature of 52°, being 62.377 lbs. per cubic foot. The 90 gallons supplied to the injector would weigh 898 lbs., which, added to the 46.5 lbs. resulting from the condensation of the steam, gives 944.5 lbs. as the weight of the water delivered. Mr. Bourne, however, gives the quantity delivered as 100 gallons at a temperature of 117°, and taking the weight of water at that temperature as 61.7 lbs. per cubic foot, this would correspond to a weight of 987 lbs., or $42\frac{1}{2}$ lbs. more than as determined above. This difference is, however, not greater than might be naturally expected in experiments of this kind, in which, unless many minute precautions are taken, there is a considerable liability to small errors arising from the expansion or contraction of the measuring tanks, etc. If, in the present instance, we take the larger quantity, or 100 gallons, as that actually delivered by the injector, we shall have 16 c. ft. of water delivered against a pressure of 30 lbs. per sq. in., or 4,320 lbs. per sq. ft., this corresponding to the performance of $4{,}320 \times 16 = 69{,}120$ foot-pounds of work. Dividing this number by 772 (Joule's equivalent), we get $\frac{69{,}120}{772} = 89.5$ as the number of units of heat actually required to perform this work. But it has been shown that the steam abstracted from the boiler parted with 50,266.5 units of heat, and there therefore remains 50.177 units of heat to be yet accounted for. But it is stated that the 898 lbs. of water supplied to the injector were heated from 52° to 117°, and this would, therefore, correspond to the absorption of $898 \times 65 = 58{,}370$ units of heat, or more than sufficient to account for all the heat lost by the steam. We, of course, do not for a moment suppose that any heat was created in the injector, and the fact that the amount of heat stated to be imparted to the feed-water exceeds by a small amount that lost by the steam, can only be due to some errors of observation.

Some of Mr. Bourne's experiments were conducted with the injector delivering against both higher and lower pressures than that at which the steam was supplied; indeed, in one instance the injector, when furnished with steam at 20 lbs. pressure, was made to deliver against a pressure of 100 lbs. In this case, however, the quantity of water which escaped at the overflow was equal to 80 per cent of that actually delivered by the instrument. It will be unnecessary that we should repeat the detailed calculation which we have made concerning these various experiments, but we may give, for the purpose of comparison, the results obtained in two instances in which the pressure against which the water was delivered were respectively much lower and much higher than that at which steam was supplied. These details are as follows:

	A.	B.
Duration of experiment....	9 min.	16 min.
Pressure in boiler	40 lbs.	30 lbs.
Pressure against which water was delivered...........	10 lbs.	90 lbs.
Quantity of water evaporated	6 gals.	6 gals.
Quantity of water drawn from supply tank	94 gals.	96 gals.
Quantity of water delivered into reservoir tank	100 gals.	100 gals.
Quantity of water escaped at waste pipe	..	6 gals.
Initial temperature of water,	60° Fahr.	52° Fahr.
Final temperature of water,	116° "	114° "
Units of heat abstracted from steam.............	60,245	60,320
Units of heat imparted to feed-water	52,175	57,766
Units of heat due to work done	29.8	268.5
Units of heat not accounted for above...............	8,040.2	2,285.5

In the case of experiment B, the 2,285.5 units of heat, entered as "not accounted for," were probably carried off by the water which escaped by the overflow pipe. It is worthy of remark, that in the two experiments, of which we give the particulars above, the same volume of water was evaporated and the same quantity delivered, notwithstanding that the circumstances were so different in the two cases. Inasmuch, however, as the temperature of 40 lbs. steam is 287°, and that of 30 lbs. steam 274.4°, the six gallons of water evaporated would, in experiment A, weigh 55.56 lbs., and, in experiment B, weigh 55.84 lbs. It is also probable that if the measuring arrangements had been sufficiently delicate, some other minute differences in the quantities would have been observed.

In conclusion, we think that Mr. Bourne's experiments fully corroborate the opinion which we have on many occasions expressed in this journal, that the injector, while forming an excellent and economical boiler-feeder, is not by any means adapted for raising water or for supplying water under pressure, except in those cases in which the heat imparted to the water delivered can be turned to useful account. While, however, we consider that Mr. Bourne's experiments are of much practical interest, we cannot but regret that a supplementary series was not carried out with a donkey pump of good arrangement, substituted for the injector, the exhaust steam being utilized in heating the feed-water. Some useful comparative results might have been thus obtained, though we doubt whether the measuring arrangements were sufficiently delicate to enable the comparative efficiency of an injector or donkey pump for feeding boilers to be ascertained with accuracy. A thoroughly reliable series of experiments to determine this point is really required, and we trust that some day it will be undertaken. In the meantime our own predilections are in favor of the injector, always supposing that the use of that instrument does not necessitate the employment of cold feed-water where hot feed-water would otherwise be available.

WOODEN RAILWAYS.—During the late war in America the Confederates, in constructing temporary railways and renewing lines which had been destroyed, were compelled on many occasions to use wooden rails as the only kind procurable, and over these rails they transported altogether thousands of tons of baggage, etc., at what, all things considered, were very fair rates of speed. Wooden railways in fact, when properly maue and worked, are by no means bad things in their way, and in countries where timber suitable for their construction is abundant, they may often serve a good purpose by opening up a traffic which as it increases will warrant the establishment of an orthodox iron road. It was a recognition of these facts which some nine or ten years ago led Mr. J. B. Hurlbert, an American engineer, to construct a wooden railway about six miles in length for light traffic, and the results obtained with this line proved so far satisfactory that early last year a line, 47½ miles in length, was constructed to connect Carthage, N. Y., with Harrisville. More recently, also, Mr. Hurlbert has built a line in Canada extending from the Clifton Iron Mines to the Otwegatchie Railway, a distance of twenty-two miles, and it is of this line that we more especially intend to speak here.

The rails of the Clifton Wooden Railway, like those of the Harrisville line already mentioned, are of maple, and are 14 ft. long, by 4 in. wide, by 6 in. deep. They should be laid "heart side" down. The sleepers, or "ties" as they are called in the States, are notched for a depth of 4 in. to receive the rails, and the latter are secured in the notches by wedges of maple plank 4 in. wide and 12 in. long. The switches are made in the usual way. The gradients on the line are in some places as steep as 1 in 15, and the sharpest curves are of but 250 ft. radius, these curves, however, being somewhat exceptional. The engines which have, until lately, been used on the line weigh 10 tons without wood or water, and their load averages from 30 to 40 tons. More recently heavier engines weighing 20 tons have been placed on the line, and it is expected that when the latter has been strengthened these engines will take loads of 60 or 80 tons over the railway from the mines to Ogdensburg, there being for this distance a general fall in the direction of the traffic, although the latter has to ascend in some places gradients varying from 1 in 68 to less than 1 in 60. It is stated, moreover, that on these wooden roads a 14-ton engine can draw easily 20 tons of freight up an occasional gradient of 1 in 21; and the experience of last winter has shown that ice and snow are no worse on a wooden railway than an iron one, the use of a snow plough and sand having enabled the Clifton line to be worked regularly in the winter season, even when the ground was covered with three or four feet of snow. The wheels of the rolling stock used on the line have rims similar to ordinary railway wheels, but a little wider, and the flanges are slightly beveled, so that they may bear against the rails without cutting them.) The trains are run at from 8 to 12 miles per hour, and these speeds can be maintained with safety; indeed, it is stated that no truck has been off the line since the Clifton Railroad was opened for traffic.

The quantity of maple used per mile for rails is about 22,000 c. ft., and it is stated that the cost for labor of placing these rails in position is from $80 to $100 States currency. Besides this, there is the cost of the "ties," and wedges, etc., and altogether it is stated that the complete cost of making and laying a wooden railway of a somewhat superior class to that of which we have been speaking, including a moderate allowance of rolling stock, sufficient for the traffic of the first few years, will not exceed $5,000 per mile. In many instances, in fact, such a line as the Clifton Railway can be constructed, exclusive of rolling stock and large bridges, for $1,000 or £200 per mile. As regards the cost of maintenance, that, of course, depends mainly upon the amount of traffic; but in the case of the Clifton Railway, Mr. Hurlbert states that two men will suffice to keep in order three miles of line, replacing all worn rails that may be necessary. Altogether, we think that sufficient evidence has been afforded by the working of Mr. Hurlbert's wooden railways to show that such lines may be profitably constructed in many cases where, from the nature of the country, the formation of a regular railway would be scarcely warranted. It must be remembered, also, that a considerable portion of the labor involved in the building of a wooden railway could be turned to useful account whenever, from an increase in the amount of traffic, its replacement by an iron road became desirable, while the rolling stock, even if specially built for the wooden road, would also be available on the iron one.—*Engineering.*

AËRO-STEAM ENGINES.

From a paper read before the British Association by RICHARD EATON, Esq.

It is now pretty generally allowed that power and heat are convertible terms, and we have it upon the highest scientific authority that a unit of heat is equivalent to 772 foot-pounds. We are further informed that one grain of coal produces, by combustion, sufficient heat to raise the temperature of one pound weight of water through 1.634° Fahr. Taking the mechanical equivalent of heat at 772 lbs. per unit, as above stated, it follows therefore that the combustion of one grain of coal = 1,261.45 foot-pounds.

Now, with the best pumping engines, either on the "Cornish" or "Woolf" system, the average duty is equivalent to about 94,000,000 foot-pounds, with a combustion of 94 lbs. (1 bushel) of Welch coal; in other words, 143 lbs. per 1 grain of coal as compared with 1,261.45 lbs., whence it appears that the steam engine, in its most improved state, is not able to develop much more than one-tenth into *useful* power of the *mechanical* power due to the combustion of coal. As a rule, we may assume that the more distant the extremes of temperature in a thermodynamic engine, the larger will be the proportion of heat turned into power.

In the steam engine the extremes of temperature, or the difference in the temperature of the boiler and condenser, is *not* very great, and air engines, therefore, in which greater extremes may be employed, offer certain advantages in the production of power. But in their arrangement, construction, and practical working, many difficulties occur.

The difficulties in question arise, 1st, from the destructive action of the heating furnace upon the generator, which, when unprotected by water, is sooner or later burnt out or destroyed. 2d. When high temperatures of air are employed, the wear and tear of working parts becomes very great, and the difficulty of proper lubrication almost insuperable. On the other hand, if *low* temperatures be employed the engine develops but little power in proportion to its size, and the consumption of fuel becomes quite as large if it does not exceed that of ordinary steam engines.

In the consideration of the subject before us a useful lesson may be learnt from the avocations of domestic life. Let the tea-kettle be our monitor. The careful housewife places it duly cleaned and charged upon the fire, and no matter how sharp and clear may be the draught, nor how vivid and intense the gaseous flame, no harm ensues. Let her, however, neglect to keep it replenished, and what occurs—the bottom is destroyed. The water acts as a shield or safeguard to the metal exposed to the vivid incandescence, and in the present state of our knowledge as to the structure of metals, or their behavior when exposed to sharp heat, it is difficult to devise a better protection.

The difficulty above mentioned has hitherto proved insuperable notwithstanding the best efforts of those apostles and pioneers of the air engine—Stirling Ericsson and others. All the ingenuity expended upon the designing and construction of regenerators for utilizing to the utmost the heat of the escaping air, proved unfortunately of no avail so long as the generator, which was the mainspring of the whole, to say nothing of the working cylinder itself, remained liable to premature destruction.

Mr. George Warsop, of Nottingham, as the son of an air-gun maker there, was born with aerial ideas, which, although his only education was received at a Sunday School, and he was sent to work at ten years of age, he turned that education to such good account that before he was twenty he had in leisure moments secretly constructed an air engine. Later in life it was his privilege, whilst a working mechanic in New York, during his engagement with Mr. Ericsson, to observe the weak points in the system of that highly gifted and persevering inventor, and after years of research to supply the deficiencies by a marvelously simple system of mechanism, which, as far as present experience goes, promises complete success by means which, happily for the cause of economy and progress, are compatible alike with physical science and mechanical construction.

It is proposed, firstly, to describe these means; secondly, to enumerate the carefully ascertained comparative results which have followed their application; lastly, to show that these results are in accordance with sound theory.

In the first attempts at practically carrying out the system, the arrangement adopted was an ordinary high-pressure engine, with vertical boiler, as used in the midland counties, where fuel is cheap. An air-pump is added, which is put in operation by the action of the steam engine.

Thus, cold air is taken in by the air-pump, and is forced on in its compressed state through an air-pipe, which, in the case before us, is connected first within the exhaust, then in a coiled form down the funnel of the boiler, then past the fire, and finally past a self-acting clack valve at the bottom of the boiler into the boiling water itself, rising naturally through the water, the air is intercepted and subdivided by diaphragms of metal gauge. Thus a twofold service is rendered by the contact of the elements, the water becoming acrified and deprived of its cohesion and prompted to a free ebullition, whilst the air on rising above the water is saturated by the steam, and the two together pass on to their duty in the cylinder, where saturation assists lubrication. The agitation of the water prevents scaling.

The machine thus constructed, but having two air-pumps, and with cam motions applied to the valves as also to the poppet valves of the working cylinder, gave the following results, results which it must be admitted were sufficiently discouraging to have deterred the inventor and his associates from proceeding further in the matter, but for their faith in the intrinsic soundness of the system, and perseverance in carrying it to a practical issue. The work had to be done under disadvantages of various kinds, on inconvenient premises, which centuries back were a farmhouse standing within the ancient walls of Nottingham, and until the protection of the patent laws had been obtained, the original apparatus was carefully guarded in an unsuspected attic.

The results I proceed to detail:

TABLE NO. I.

Combined Air and Steam Engine.

Coals consumed during experiment.	Weight on brake.	Duration of experiment.	Number of revolutions of brake.	Number of revolutions of brake per minute.	Gross H.P. of useful work done.	Gallons of water evaporated during experiment.
lbs. 110	lbs. 75	min. 140	4,623	33	182	84
Steam Engine only.						
lbs. 110	lbs. 75	min. 115	5,182	45	204.1	66

It is needful to state that the amount of air passed in the boiler in a state of compression was considerable, being as much as 43 per cent of the effective cubic contents of the working cylinder, or consumption of combined fluid from the boiler. And it appeared pretty certain that the power obtained by the increase of volume of the air admitted (due to the treating of it), did not compensate for the power consumed in working the two air-pumps which forced it into the boiler. At the same time the difference in the useful effect in the two modes of working did not appear to be so great as the power required in handling the pumps led one to suppose it would be. Hence, there appeared an evidence of a certain latent gain which needed only development. To effect this, one of the air-pumps was discarded, and experiments made by means of waste holes drilled through the walls of the remaining one to ascertain what proportion of air admitted to the boiler fully compensated for the cost of compression. And it was found that about 10 per cent of the effective consumption of fluid in the working cylinder gave much more favorable results. At the same time the cam motions were discarded, and the air-pump valves left to their own unaided action. The results are given in the subjoined table:

TABLE NO. II.

Combined Air and Steam Engine.

Coals consumed during experiment	Weight on brake.	Duration of experiment.	Number of revolutions of brake.	Number of revolutions of brake per minute.	Gross H.P. of useful work done.	Gallons of water evaporated during experiment.
lbs. 140	lbs. 124	min. 195	8,463	43.4	551 1	104.3
Steam Engine only.						
lbs. 140	lbs. 124	min. 145	5,942	41	386.9	64

Percentage of gain in work done by combined engine, as compared with that done by steam only, 42½ per cent.

Here, although a very remarkable relative economy was apparent, it became obvious, on consideration, that danger of mistake would arise in assuming this economy as absolute, inasmuch as the duty performed, when contrasted with that obtained from engines of standard types, actuated by steam, was manifestly low, and it seemed probable that, as by judicious improvement in details, the duty was made to approximate more closely to fair steam-engine duty, this relative economy might fall off considerably, inasmuch as there would be less margin to economize upon.

With the view of testing this point, and also for the satisfaction of railway engineers, of conducting experiments at locomotive pressures, a thorough remodeling of the whole apparatus was effected. The tappet motions were thrown aside in favor of the usual slide-valve arrangement, working with a moderate amount of expansive action. The former wasteful vertical boiler was discarded in favor of a more economical one, of the compound or Cornish multi-tubular description, so as to obtain a better evaporative duty from the coal consumed. The radiating surfaces of the cylinder pipes were re-clothed, and the feed-water heated by the exhaust steam. Instead of exposing the air-pipe to the direct heat of the furnace, as in the former case, the air became thoroughly heated on its passage from the pump to the boiler to a temperature of from 500° to 6,000° Fahr., by being conducted through suitable coils and pipes through the exhaust steam in the heater, and the waste heat in the boiler flues and uptake.

The general arrangement adopted is shown by the accompanying drawings. The air is forced by the air-pump through a tube of ordinary wrought-iron, and of 1¼ in. internal diameter, into coils in the regenerator, which is heated by the exhaust steam, thence in a straight line to the uptake, down which it passes through a coil into the flues beneath the boiler, and through another coil in the smoke-box, thence back to the front of the boiler and past the clack valve, and is led down by an internal bend to the bottom of the boiler water space, where it is evenly distributed along the whole length by a perforated pipe, and the results are given in the following tables, Nos. III and IV:

TABLE NO. III.

Combined Air and Steam Engine—Even Pressure trial.

Coals consumed during experiment.	Weight on brake.	Duration of experiment.	No. of revolutions of brake.	No. of revolutions of brake per minute.	Gross H.P. of useful work done.	Gallons of water evaporated during experiment.	Weight of fire left in furnace when engine was stopped.
lbs. 112	lbs. 120	min. 153	15,433	nearly 101	972.55	93¾	lbs. 53½
Steam Engine only.							
lbs. 112	lbs. 120	min. 112	10,500	93¾	661.69	68¾	lbs. 34

N. B.—These trials were conducted on the same principle as that followed by the Royal Agricultural Society, the engine being stopped in each case when it ceased to perform 90 revolutions per minute.

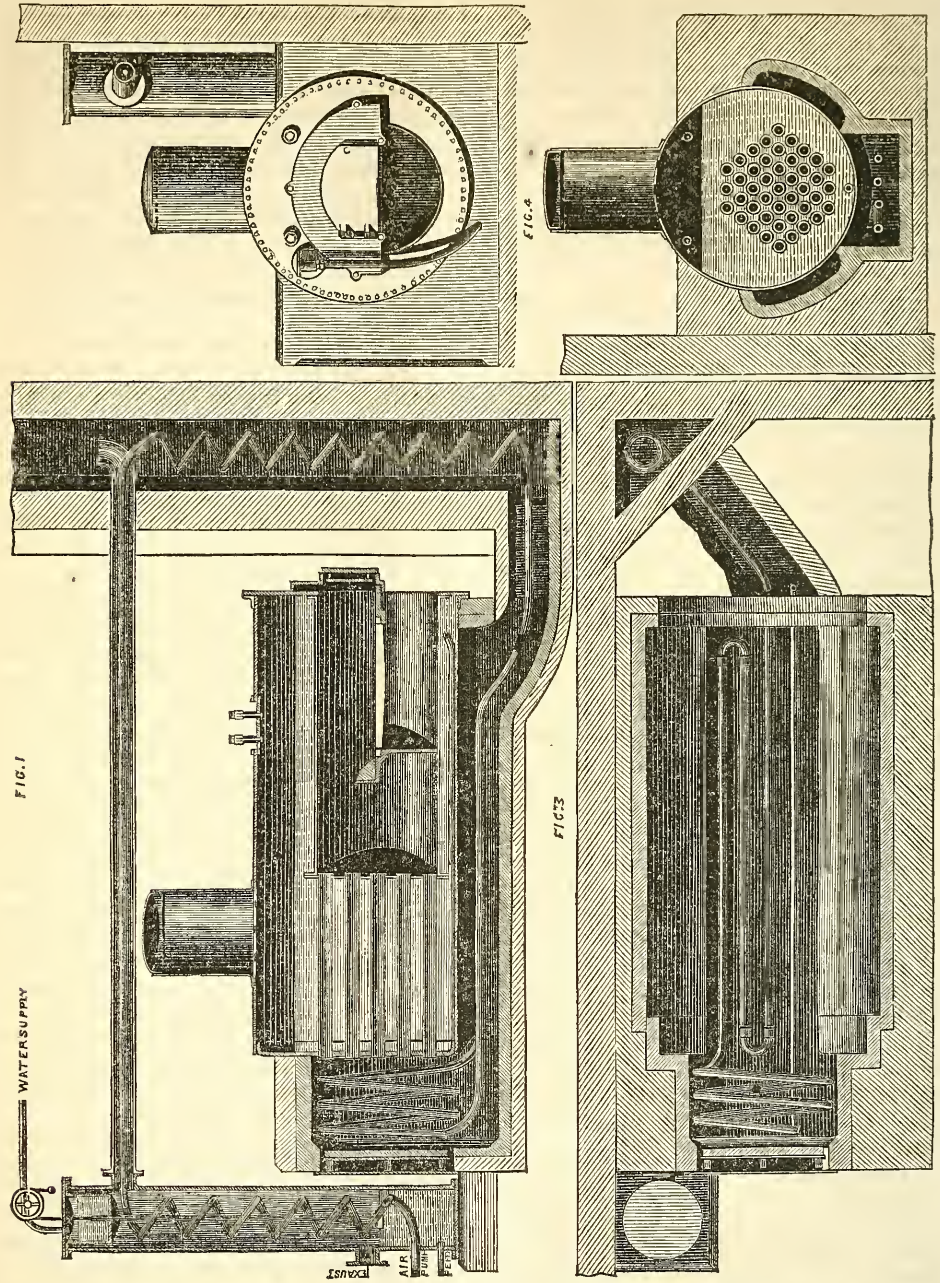
Percentage of gain in work done by combined engine, as compared with that done by steam only, 47 per cent.

TABLE NO. IV.

Combined Air and Steam Engine—Open Valve trial.

Coals consumed during experiment.	Weight on brake.	Duration of experiment.	No. of revolutions of brake.	No. of revolutions of brake per minute.	Gross H.P. of useful work done.	Gallons of water evaporated during experiments.	Weight of fire left in furnace when engine stopped.
lbs. 140	lbs. 120	min. 234	22,815	97.5	1,428.05	131.25	43[illegible]
Steam Engine only.							
lbs. 140	lbs. 120	min. 196	17,825	90.94	1,115.7	112.5	lbs. 28¼

Percentage of gain in work done by combined engine as compared with that done by steam only, 27.994 per cent.



The pipe through which the air is forced into the boiler by the action of the air pump is of iron, and is $1\frac{11}{16}$ in. in diameter outside, and $1\frac{1}{4}$ in. bore. On leaving the pump the pipe is first led to the heater, shown on the left of the engraving, wherein it is exposed to the exhaust steam. The heater consists, as will be seen, of a cast-iron cylindrical vessel placed in a vertical position, and provided with two branches—one near the bottom and the other near the top—through which the exhaust steam respectively enters and escapes from the casing. At the top of the heater is placed a small cylindrical tank exposed at the bottom and sides to the exhaust steam, and perforated around the upper part of the sides, so that in the event of its receiving an excess of water, the latter may overflow and fall to the bottom of the heater. Through a stuffing-box at the bottom of the tank there passes a tube provided with a rose at the lower end, this tube being carried by a float, which swims in the water at the bottom of the heater, as shown, and, by means of a cord passing from the top of the tube, works a cork, which regulates the supply of water to the tank at top of the heater. The action of this heater will be readily understood without further explanation, and we need merely add that it furnishes a steady supply of hot feed-water at a temperature of from about 195° to 200°.

The air-pipe, after leaving the heater just described, passes along the exhaust pipe to the chimney, and descending the latter spirally, as shown, passes into the flue beneath the boiler. Here it is led backwards and forwards, as shown in the plan, and after making several convolutions in the smoke-box, is led back to the front of the boiler, where it communicates with a valve-box containing an ordinary light clack-valve. The object of this valve is to prevent water from entering the air-pipe when the engine is stopped. From the valve box a pipe is let down within the boiler to the bottom of the latter, this pipe being perforated at intervals on the upper side. The perforations are placed closer together at the further end of the pipe than they are at the end at which the air enters, and by this means an equable distribution of the air at the different parts of the boiler is insured.

The lengths of the various portions of the air-pipe are as follows: In feed-water heater 12 ft.; in exhaust-pipe 13 ft. 6 in.; in chimney and flues, including coils in smoke-box and under boiler, 58 ft.; total, 83 ft. 6 in. The total external surface exposed by this pipe is thus about 36¾ sq. ft.

The principal dimensions of the boiler are as follows: Length, 8 ft.; diameter of shell, 3 ft. 6 in.; diameter of fire-box flue, 2 ft. 2 in.; length of fire-box and combustion chamber, 5 ft.; and length of tubes, 3 ft. The tubes are 41 in number, most of them being $2\frac{5}{8}$ in., and some of them $2\frac{5}{16}$ in. diameter. The total effective heating surface exposed by the boiler is about 130 sq. ft.

It is right to mention that in all the before detailed experiments, the "Prony" brake with the best modern improvements was used as the measure of useful work done, and *every care* taken in the conduct of these trials to determine accurately the amount of water evaporated, and the duty done in useful effect by a given amount of fuel.

Other observations as to temperature, indicator diagrams for determining the cost of the air compression in proportion to the power developed, and various useful notes were obtained, which it would be out of place to recapitulate here at length, but all these details are at the disposal of the Association, or any scientific persons interested in the subject.

Professor Tyndall has volunteered to investigate the scientific bearings of the results which have been personally observed in Nottingham by that accomplished amateur engineer, Lord Richard Grosvenor, and by other engineers, several of whom have already applied to be licensed to make.

It remains to submit to your consideration the theory of our system. We have here a machine which, when worked as an ordinary steam engine and boiler, performs as respectably in its brake duty as an average well-constructed commercial engine, not designed to work with a high rate of expansion, and we find that the addition of the pneumatic arrangements considerably enhances the amount of its useful duty.

Let us now endeavor to ascertain in what manner the gain in question arises, premising that the following condition of things can exist only in theory. Suppose a boiler to be theoretically perfect, wasting no heat, and its feed level maintained only just constant, the quantity of water evaporated being infinitely small, and friction of all kinds to be eliminated in the machinery. Then the power required in compressing any given amount of air at atmospheric density will be recouped by the power generated by the re-expansion of the air so condensed, action and re-action being equal.

Let us now ascertain the cost of obtaining a given quantity of steam at a given pressure, as compared with the like quantity of air at the like pressure, and for the sake of example we will take 150 c. ft. in each case at 60 lbs. pressure per square inch in gauge. Here the relative volume of the steam to the water which generated would be in the case of 60 lbs. pressure (307° Fahr., about) = 355 to 1, according to Regnault. And it follows that the 150 c. ft. of steam under consideration was generated from 1.355th of its volume of water originally, or .422 c. ft.

The weight of one cubic foot of water being 62.32 lbs., the weight of .422 c. ft. would be 26.3 lbs. Now, to raise 1 lb. of water from 62° Fahr. to 212°, or through 150°, requires 150 heat units; to convert it from water at 212° into steam at any pressure, 966 heat units; total gross units, 1,116; and as the conversion thus of 1 lb. of water requires 1,116 heat units, it would follow that the conversion of 26.3 lbs. of ditto would require 29.350 heat units, which is the cost of obtaining 150 c. ft. of steam at 60 lbs. pressure. In the case of the air, 500 c. ft. of atmospheric density and temperature, 62° would, by Mariotte and Dulong's law, be transformed into 100 c. ft. at 60 lbs. per sq. in. on gauge, supposing the temperature remained unchanged. But this 500 c. ft. of atmospheric air is, by the combined agency of the increase of temperature, due to compression and the application of artificial heat in some form brought from its original temperature of 62° up to that of the boiler, viz: (that due to 60 lbs. pressure,) 307°; in other words, through 245° Fahr. Now, the weight of 500 c. ft. of atmospheric air = 38.05 lbs., that of 1 c. ft. at atmospheric density and 62° temperature being = .761 lbs., according to Regnault's experiments. And we have seen that this 500 ft. at atmospheric density, and 62° temperature, is equivalent in value to 100 c. ft. at 60 lbs. pressure and the like temperature, the weight therefore would be alike = 38.05 lbs.

The increase of volume from 100 c. ft. due to the increase of temperature from 62° to 307°, or through 245° would be, according to the general formula applicable to the expansion of gases, about 50 per cent, or, say roughly, as the volume would increase 1-480th of its bulk for each degree Fahr. increase of temperature; for 245° increase, the original bulk, 100 c. ft., would be increased 245-480ths, which is about 50 per cent, the original 100 c. ft at 60 lbs. pressure per square inch now becoming 150 at the like pressure, and this weighing 30.05 lbs. The number of units of heat which will be consumed in raising the temperature of this 38.05 lbs. of air from 62° to 307°, or through 245°, the pressure remaining constant and the volume variable, as above described, will, according to Regnault, bear the same to that which would raise the same weight of water through the same amount, as 238 to 1.

38.05 lbs. × .238 × 245° range through which raised = 2,218.69 heat units, which is the cost of obtaining 150 c. ft. of air at 60 lbs. pressure, as compared with the 29,350 heat units before mentioned in the case of the like quantity of steam, a very striking and remarkable difference. Both these 150 c. ft. are capable, when worked in a cylinder, of generating the same motive force, and are alike capable of being worked expansively, but it is an important consideration whether the loss in working the air expansively would not be greater, owing to its more rapid radiation and loss of heat and consequent loss of volume and pressure.

A further series of experiments are about being made with the view of ascertaining the results due to working at higher pressure and rates of expansion, and here thorough jacketing and maintenance of the temperature of the working cylinder will doubtless prove most valuable.

Such a theoretical gain, viz: about 13 to 1, is evidently vastly far from being realized in the experimental engine, seeing that only about 13 per cent of the whole cylinder consumption in the last experiment is passed into the boiler (in place of 100 per cent, as in the investigation above given), the remainder being supplied by the steam generated, thus 13 per cent air + 87 per cent steam; and we must look to other causes, in addition to the above, to account for the economy realized in practice. It is conceived that it is to the injection of air into the boiler that this may mainly be referred for the following reasons. When steam is ordinarily raised from water, the heat expended is consumed partly in overcoming the cohesion of its particles, and in creating steam room for the vapor raised, and, further, in promoting the circulation of the water itself in the boiler. In all of these operations work is done, and the injection of the air accomplishes practically the work which, under the above mentioned circumstances, would have to be done by the heat, a much more intense and rapid circulation of the water is achieved, and the rapid ebullition and giving off of steam bubbles is greatly promoted. Further, the air enters at a high temperature, and its *direct* action upon the water is equivalent to an increase of evaporative surface, all the more efficient from being direct instead of communicated by the conductive power of metal plates. It is to be regretted that some more certain method than the usual high grade thermometer has not yet been devised and applied for, measuring the temperature of the incoming air, which is the best absorbent of waste heat in the boiler flues, which can well be devised, and, according to present experience, a very perfect agent in transmitting it into mechanical force. In short, the change of condition which occurs in the boiler immediately on the admission of air may be best realized by imagining the tubes and tube-plates to be suddenly removed and replaced by an indefinitely large number of tubes of infinitely small diameter, permeating the water and increasing the ebullition and disengagement of vapor bubbles by an agitation almost mechanical.

An experiment, which has been repeatedly made, goes far to confirm this view. Let the engine be running under steam, the pressure gauge rapidly falling, with the fire fast dying out, the putting the air-pump in gear will cause the gauge to mount several pounds in the course of a few minutes, and there continue for a considerable time, the engine meanwhile continuing to work as before, after checking a moment or two on first feeling the increased resistance due to putting the air-pump in action. And this result evidently shows that the evaporative duty of the boiler is increased immediately on the admission of the air, and irrespective of the state of the fire—a state of things which is consistent with the foregoing explanation, and, indeed, scarcely susceptible of any other.

Even did time permit, this possibly is not a fitting occasion for more than a passing glance at the social or commercial bearings of this discovery. As our navy and Government workshops can thereby be coaled at far less cost than hitherto, taxation may be reduced. Agriculture will be an immense gainer in the impulse given to steam cultivation in all its branches, no trifling consideration in view of the fact that in the month of May last one English firm turned out 102 portable engines. Manufactures of all kinds, where steam-power is used, will be cheapened, the sailing vessels of our mercantile marine will be rapidly transferred into auxiliary steamers able to traverse the Suez canal and the Red Sea, towards which all eyes are now turned. Communication with all parts of the world will be cheapened and facilitated. There are good grounds for expecting that railway dividends will improve. It is estimated, by way of example, that the Metropolitan line would save £6,000 per annum in fuel and water, whilst the ventilation of its tunnels would be improved, and the additional power, gained at a trifling outlay, would enable each engine to draw two more carriages than at present. Our mines, our water-works, our drainage operations, and our quarries will share in the general gain. Our mechanics, now quitting, with weeping eyes and aching hearts, the land of their nativity, because they have no work, will have enough and to spare, through the impulse given to the construction of new engines and the adaptation of old ones. Nor will the colliery-owner suffer, as is proved by the cordial satisfaction already expressed in that direction.

Opportunely does this discovery come in 1869, the centenary of the steam-engine.

A writer, in a recent number of that valuable paper, the "Economist," remarks that "a single improvement, to save 10 per cent in fuel for the steam-engine, would probably add more absolutely to the real wealth of this generation than the invention of the steam-engine itself added to the real wealth of the generation in which it was invented." After years of anxious research we now possess such an improvement, but of greater value. We are thankful for the opportunity of doing good in our day and generation.

THE REMOVAL OF SILICON FROM PIG IRON.

Abstract of a paper read by Mr. J. PALMER BUDD, before the Iron and Steel Institute.

In the Welsh ironworks, the pig iron is principally white. The whole of the forge cinder made is put on the blast-furnaces; and cinder in large quantities is purchased in addition from the tin plate and other neighboring forges. A large admixture of Lancashire and Cumberland and other hematite ores is put on the furnaces as a corrective. The furnaces are driven hard; and the white is of course inclined to be sulphury. The plan of working is to refine, before puddling, from a half to a third of the white in refineries placed before the blast-furnaces, potting the iron into them. The yield of these fineries from molten iron is about 23 cwt. of pig or cast iron to the ton of refined metal; the consumption of coke is 5 or 6 cwt. to the ton; and the total expense of the refinery process from 10s. to 15s. a ton. In some works the puddling furnaces have one-half white pig and one-half refined iron; in others, the proportion is one-third refined metal, one-third white pig, and one-third mine pig, made without cinder from argillaceous mines and hematite ores. Soft Lancashire ore is freely allowed for fettling the puddling furnaces. The popular notion is, that the white iron is decarbonized in the refinery process, and freed from sulphur and phosphorus. Messrs. Crace Calvert, and R. Johnson, Dr. Percy, and other authorities, have shown conclusively that this popular notion is unfounded. They have proved that all cast iron contains a notable proportion of silicon varying from 1 to 6 per cent (the grayer the iron the greater the proportion of silicon), which is reduced in the blast-furnace, and combined with the iron from its earthy base, silica.—It is silicon which imparts its casting property to pig iron; when removed, cast iron is only semi-fluid, although it may retain all or nearly all its carbon. From its greater affinity for oxygen than carbon, silicon protects the carbon in pig iron from the action of oxygen; even when it is present in the small proportion of 1.500 per cent no carbon is burnt off. Silicon is, in many of its properties, very analogous to carbon; and the refining process instead of being called a decarbonizing, might be better described as a desiliconizing of the iron. Now, the process he had invented desiliconized the iron as tapped from the blast-furnace without wasting the iron, and without any extra expense whatever beyond the usual cost of the pig; nay more, it was more economical to make than pig iron. The process must therefore revolutionize the present practice in the iron trade. His usual mode of proceeding was to place a series of iron moulds similar to those used before a refinery, as near as convenient to the top hole of the blast-furnace. He made a paste by moistening with water soft hematite ore, which, if gritty, is previously ground, and he threw a bucketful, containing about 60 lbs., into the mould in a semi-liquid state, and spread it evenly on the bottom and sides. The mould being quite hot from the previous cast, dries the paste, which adheres to the bottom. He then pots as much iron as is required from the blast-furnace, and allows it to run over and fill the moulds to the depth of three and a half to four inches. A great ebullition took place; jets of flame of a peculiarly white color burn on the surface, which he assumed to be the combustion of silicon in the oxygen abstracted from the hematite. It was proved by repeated analysis that whilst the silicon was 1 per cent in the white cast iron, it is reduced by this simple process to .200 to .300 per cent, or from 1 per cent to 1-500th, a cinder is thrown up containing silicon, some phosphorus, and sulphur. The carbon is hardly at all removed. The appearance of the iron after the process is that of refined metal.—For want of a sufficient upward impulsive force, a good deal of the scoriæ, although chemically separated in the process from the iron, is not removed from it mechanically, but is mixed with the refined metal; and, on remelting in a puddling furnace, forms a protecting slag. The cost of the process is nil, as the iron contained in the hematite is reduced, and adheres as cast iron to the bottom of the iron in the mould. There is no sand or coke dust used; and the refined iron goes clean into the puddling furnace. The yield in puddling is, that of refined iron, about 21 cwt. to the ton of puddled bars.—The puddlers like to have one or two pigs of white, with the metal so refined, as they say it works more "liquory"—showing that when the silicon remaining is only .200 or .300 per cent, the charge does not possess the necessary fluidity. The puddling furnace keeps longer in repair; no other fettling is used; and hammer slack and the former allowance of shearings to make scrap balls has been discontinued. The men do more regular work; and, like the refined iron, the yields are larger. The puddled iron is of an improved quality, and much liked in the rail mills. The second process was the same as the first, only that he mixed two-fifths by weight and half by bulk of nitrate of soda with the hematite ore, which is formed into a paste, and applied in the same way. With this mixture, the ebullition is greater; the flame is of a yellowish color—showing the ignition of some of the soda. The cinder is thrown up and out of the iron, over which it forms a crust, which can be separated when cold. The iron has a cellular and honey-combed fracture, like metal much over-blown. The scoriæ contain sulphur, phosphorus, silica and soda. The iron works drier and cleaner, and to a better yield than that made by process number one, but should have about one-third of gray pig added to make a very clean and rough iron. The only cost of the process is the nitrate, which in the proportion named comes to about 4s. per ton at its present high price. The saving by the process was very considerable, and it was not confined to white iron, though it was then most efficacious. The author added: "In my opinion, the money value of my invention to the iron trade will be enormous; greater, perhaps, than that arising from the use of the blast-furnace gases, said to be a £1,000,000 a year, and which I first introduced into this country and made known to the iron trade at the meeting of the British Association held at Swansea, in 1849."

ASPHALTED SURFACES.

From the "Mechanics' Magazine."

A mixture of the ordinary coal gas tar and common gravel constitutes nine-tenths of the so-called asphalte, and it is no wonder, when the spurious article is passed off for the genuine, that the latter suffers in the estimation of the public, and many refuse to believe in the durability and efficiency of an asphalted surface. This is the natural result of the very cheap and very bad footpaths and platforms that have been laid down in numerous localities and composed of the ingredients referred to. A surface thus constructed will, in spite of the imperfect nature of its components, if the formation of it be carefully attended to exist for a time in a smooth and apparently sound condition. This appearance is, however, deceptive. The influence of wear and tear, combined with the action of wet, speedily produces hollows and irregularities, cracks and crevices extend their ramifications in every direction, and the opposite effects of heat and cold are equally active in the work of disintegration and destruction. The one renders it sticky in summer, and the other brittle in winter; the whole mass soon breaks up and has to be removed, to the loss and disgust of those who laid it down, and who register a vow never to employ "asphalte" again for any purpose whatever. If we now consider the difference between the spurious and genuine articles, it will not be surprising that the former has no claims to the title that belongs properly to the latter. Instead of being the hasty result of a mixture of tar and sand or gravel, the genuine asphalte has a very different composition. Its chief ingredient is derived from a natural production, drawn from foreign quarries, or mines as they are generally termed. At present, there are very few of these mines, of which the best known is probably that of Pyrimont. The raw material arrives in the form of dark-colored amorphous lumps containing a large proportion of bitumen, which is extracted by the employment of suitable mechanical means. One of the principal components of bitumen, according to the nomenclature of M. Boisingault, is the substance asphaltene. It has a chemical composition represented by the formula $C_{20}H_{16}O_3$, and we recommend it to those whom it may concern as an excellent name whereby to distinguish the genuine from the spurious article. When it is kept in view that, in order to obtain a material fit for manufacturing asphalte as it ought to be made, it is necessary to import the chief ingredient from Italy, it is evident at a glance that there will be a wide difference in the price of the foreign and the home production. As the price, so is the quality. A permanency and durability are obtained by the use of the extracted bitumen which cannot be expected from the wretched stuff prepared from the ingredients to which we have alluded. At the same time, it is equally necessary to ensure good and sound workmanship in the laying down of asphalte as to provide the best materials. There is a company which has portable machinery, especially designed and constructed for this purpose, which allows of a large area being covered in a comparatively short space of time. As we have deprecated the use of bad and inferior asphalte as exceedingly deceptive to the public, and prejudicial to the prospects of the only proper substance, it is but fair to give a few instances where the latter may be seen and its value appreciated. One of these is, in the words of Mr. Hepworth Dixon, "Her Majesty's Tower." Most of the footpaths, and some portions of the roof, have been laid for some years past with Pyrimont asphalte, and yet present no signs of deterioration. The roof of the new prison at Holloway, and the extensive footpaths around the fountains in Trafalgar-square, are other examples.

According to the climate and the purposes for which it may be intended, so can the composition and character of asphalte be varied. From its nature, it must always possess some little elasticity, even when that quality is required to be reduced to a minimum. This is one of its properties, which is frequently of considerable advantage. It renders it exceedingly valuable as a "damp" course in buildings, and much superior to slates, tiles, concrete, or other hard and unyielding substances. Considering them all on a par with respect to water-proof qualities, the asphalte alone possesses the capability of yielding to any local pressure. Consequently, if any portion of the foundation settle, the slates, tiles, or other hard substances at once break across, and the watertight continuity is destroyed. The asphalte, on the contrary, adapts itself to the settlement of the foundations, and preserves the water-proof layer intact. Any one who has walked over a large area of properly executed asphalte cannot fail to ask himself the question, whether its application could not be extended to road and street traffic. There is no doubt but that the substitution of asphalte for granite or macadam would be hailed with ecstatic delight by the riders of bicycles. What a road to run on! A portion of Threadneedle-street has within the last nine months been laid down with asphalte, but upon a different principle to that upon which footpaths are constructed. Some time must elapse before it will be possible to judge of the suitability of this surface for the severe tax made upon its powers of resistance and durability by the exigencies of our metropolitan traffic. There is another situation for which an asphalted surface appears to be well adapted, and in which its property of elasticity can be advantageously brought into play. It is in the case where it is necessary to form a footpath on made ground. The most extensive example of this kind is probably to be found in the foot thoroughfares of the Thames Embankment, and any one who is in the habit of traversing that on the north side cannot fail to perceive how badly the paving flags adapt themselves to the irregularities caused by the "giving" of the ground underneath. A very slight subsidence, which would be scarcely appreciable under ordinary circumstances, is quite sufficient to destroy the evenness of a flagged footway. As it is, many of the flags are disturbed to an extent which throws up one end fully an inch above its neighbor, and imparts a very jagged appearance to the surface. Taking them up and relaying them is the remedy, but how often this remedy will have to be repeated it is impossible to assert, for railway experience has demonstrated that it frequently requires a long time for a heavy embankment to settle permanently to its "bearings." In pointing out the manner in which paving flags behave under the conditions in question it is not intended to assert that they ought to be replaced wholesale by an asphalted surface, but had a small portion of the Embankment been covered by the latter substance, the relative merits of the two descriptions of paths would have been fairly and impartially tested. The principle of giving every method of executing any particular description of work a fair trial is one that needs urgent adoption by the various branches of our civil and military departments. By every method is signified every one that possesses manifest claims to consideration, and does not, of course, include the mere ideas of inventors, or hobbies of patentees which are destitute of all practical utility. But, when an individual or a company is willing to test, solely at their own expense, any plan they consider likely to effectually accomplish any desired object, they ought to be allowed to have an opportunity of so doing. It might be urged that the public ought not to be put to any inconvenience with respect to interruption of the ordinary traffic, supposing the trial concerned the taking up of any part of a street or thoroughfare. What with gas and water companies who are perpetually breaking up the streets, the public is pretty well used to such inconveniences. Moreover, as the object of all proposed improvements is to benefit the public, the end fully justifies the means. There are undoubtedly many valuable inventions totally lost to us solely because we never permitted them to be fairly and dispassionately investigated, and their practical merits submitted to the crucial test of actual experience.

SIEMENS' REGENERATIVE FURNACES.

Abstract of paper read by Mr. Josiah T. Smith before the Iron and Steel Institute.

Although, the writer said, this subject had been brought before various societies since 1862 by some of the most eminent men of the day, and for many years had been in extensive and successful operation in various processes connected with manufactures, both at home and abroad, it had, with very few exceptions, not been adopted in the iron and steel works of Great Britain. It was possible, however, that in a few years those districts which contained large quantities of inferior coal or fine slack, without sufficient bituminous principle to make it available for cooking purposes, would find that they possessed, by means of the above invention, the opportunity of supplying their requirements from such sources. While in this country it was probable that coal would exclusively be used to produce the gaseous fuel required for the regenerative furnace, in France, Belgium, and Spain they merely used wood; in Germany lignite, and peat in Italy. It was believed that the first idea of storing waste heat to be used at intervals was due to Dr. Stirling, of Dundee, who, in 1817, patented the regenerator or heat accumulator, and subsequently applied it to his caloric engine. Captain Ericsson, in 1851, also used a kind of regenerator to his air engine; but Siemens had previously, in the years 1847-8-9, taken out patents for his regenerative steam engine and condenser. None of these inventions ever came into extensive practice, and not till 1862 did the discovery really assume a shape which was at all attractive. The invention might be generally described as requiring a producer—for the volatilization of coal, wood, peat, and such like products into gases—which might be erected at any practicable distance from the furnaces to which they were to be applied; while a regenerator, divided into four compartments filled with loose fire-bricks, had to be placed under the furnaces. These regenerators were simply fire-brick chambers divided into four compartments, one on each side for the passage of gas, and two in the centre for air, with generally five ports at each end communicating with the furnaces above. The chambers were filled with fire-bricks placed in a chequered manner, and while the upper portion had to be of the best quality, those beneath would answer if they were of the most inferior description. The chemical action which took place in the producers was described by Mr. Siemens in his lecture before the Chemical Society as follows: "Air is admitted at the grate and as it rises slowly through the ignited mass, the carbonic acid first formed by the combinationof the oxygen with the carbon of the fuel takes up an additional equivalent of carbon forming carbonic oxide, which, diluted by the inert nitrogen of the air, and by a little unreduced carbonic acid, and mixed with the gases and vapors distilled from the raw fuel during its gradual descent towards the grate, is led off by the gas tubes to the furnaces." The temperature of the gas at the junction of the upcasts with the tubes was 1,250 to 1,300 degrees Fahrenheit, a rather higher point than had yet been noticed. Before it had traveled 200 ft. in the tube, with an external atmosphere of 60 degrees, the temperature was reduced to about 130 degrees. He had himself been unable to ascertain the exact quantity of heat lost by radiation in the interval, but the experiments, although not complete, were sufficient to show that the quantity was so small that at present he could see no way of economically applying it. This lowering of the temperature and condensation of the gases was of advantage in many respects. The gas being heavier, caused, in its transit through the tubes and the various downcasts, a syphon action; and thus not only drew the gas from the producers to the furnaces, but, by keeping up a slight outward pressure, prevented the admission of air through any crevice in the tubes or the expansion boxes. It also deposited the tar from the coals into a series of wells beneath; while the water in the fuel was also condensed, and thus prevented from causing a waste of metal by introducing a too great supply of oxygen into the furnaces. After noticing more in detail the application and effect of the gases, Mr. Smith added that for many months each producer at Barrow had volatilized 3 tons of coal per 24 hours, and that the greatest economy effected was when the consumption had not exceeded 50 cwt. Estimating the weight of one cubic foot of gas at the ordinary temperature of thin air to be .075 lbs., the volume of carbonic oxide, hydrocarbon, and hydrogen, from one ton of coal would be about 53,000 ft.; and the volume of nitrogen about 122,000 ft., or making together a total of 175,943 ft. The consumption of coal in the producers at Barrow being 500 tons per week, it gave an amount of gas passing through the tubes at the rate of 6½ ft. per second, of 87,000,000 cubic feet; or through the various furnaces, adding the quantity of air there admitted, of 6,600 tons. The saving of fuel by this process at Barrow was, over a period of two years, no less than 44 per cent; but the actual money saving, by the use of a particular kind of coal, had been more than one-half. The yield of the gas furnaces, taken over the same period, showed a saving of 31 per cent as compared with the work at the firing furnaces, and the amount of repairs was just two-thirds of the old cost. In these three particulars was undoubtedly to be found the chief economy; but the adoption of the system enabled them to preserve greater cleanliness and order in their works, and an entire absence of smoke met a difficulty which in the neighborhood of large towns, was every year becoming a greater grievance. There was, he admitted, a slightly increased outlay on the plant; but taking into consideration the increased capabilities as to quantity, it would be found to represent the difference in cost between the two systems.

RAILWAY WORKING.

From "Engineering."

A given line of railway has, say, 5,000 passengers, on the average to be carried daily. Whatever pair of factors of this number be taken, one represents the number of passengers per train. There may be ten trains with five hundred passengers in each, or five hundred trains with ten passengers in each; or, intermediately, fifty trains with one hundred passengers in each. As for "railway economy" there can be no question as to which of these three divisions of daily traffic would best pay the shareholders, but it is equally clear that the ten trains, of five hundred passengers each, would not suit the imperative requirements of public convenience. The passenger wishes to hail a train much as he would hail a cab. Nothing would suit him better than to have it all to himself, or to himself and his friends. So there must be a compromise somewhere. It will neither do to run a train, or even a special carriage, for every passenger who has an important engagement, and who must, or thinks he must, be off at once, nor will it do to keep equally impatient passengers waiting for even an hour so that five hundred may be packed off together. Somebody has put forth a pamphlet, from the manager's and shareholder's point of view, arguing that fewer and better filled passenger trains are essential to the recovery of railway property. The Times comes down promptly upon it, arguing, in substance, but with perhaps less force, that passengers must have trains in waiting for them whenever they happen to want them, and that if A finds it necessary or convenient to go at 11 a.m., B has a right to a train for himself at 11.5 or 11.10, and C, if not prepared to go with either, should have his train at 11.15 or 11.20. To all this we heartily agree, merely premising that A, B, and C should respectively pay for their special trains, or club the cost with their friends, desiring to enjoy their society *en route*. It is not, of course, the business of a railway company to provide passengers for every train, but conveyance merely. The passengers must come or stay away, as they choose.

But without pursuing this line of thought, it is almost needless to say that the present system of railway rolling stock is designed for long, well-filled, and, therefore, heavy trains, and this merely because such trains must occasionally, although not often, be taken. The resources of a railway company must never break down, and the engine which draws its six carriages for twenty-five out of twenty-six week days in a month must be able to manage twenty or thirty at nearly the same speed on the single remaining day of the calendar. It might be supposed that two engines could be employed for the long train, or that the train might be broken in two, with an engine to each half. But this is not the custom.

Cannot frequency of trains, however, and corresponding public convenience, be attained with rolling stock especially adapted for a given service, meaning by "service" the conveyance of a definite maximum number of passengers at a given speed? If one hundred passengers are to be taken they may as well be taken in one as in three or four carriages, although it is not to be forgotten that, with three classes, the twenty-four first class, the thirty seconds, and the forty thirds may not arrive in the exact order to which the wisdom and liberal provision of the designer and carriage builder may have designed them. There may be forty firsts, twenty seconds, and no thirds; or, possibly, no firsts at all, ten seconds, and a hundred and sixty thirds. If we could but arrive at the democratic equality of the American carriages—not that any one wishes it—we might manage the whole hundred of the company within as many seats.

But, taking our ideal, if, indeed, it be not a fair average real train, we should require ten compartments, if not eleven, and, if we say ten, between 50 ft. and 55 ft. in length for the compartments alone. As compartments, filled with passengers, they would not weigh beyond 15 tons—of course, irrespective of the springs, axle guards, axles, and wheels beneath. Now, what power is requisite to draw this weight, say upon average gradients of 1 in 100 to 1 in 200? The least calculation will show the power to be so small that a "modern" locomotive looks abominably huge and heavy in comparison. Upon the double bogie plan the ten compartments may readily be comprised within a single carriage, and at one end, at least, the carriage would be supported upon the engine (Fairlie's plan), leaving only a four wheel or six wheel bogie to support the other end, a bogie weighing, perhaps, three tons. The engine, proper, would then require to be of such power as would draw 18 tons only in addition to its own weight. Upon gradients of from 1 in 250 to 1 in 100, this weight, at 30 miles an hour, would involve a tractive resistance of but from 480 lbs. to 920 lbs. It is evident, from the very extent of these resistances, that a tank engine of ten tons' weight would be sufficiently strong to overcome them as well as its own resistance, or, say, 28 tons in all, giving an average resistance on gradients of, say, 1 in 140, amounting to less than 1,000 lbs., which, at 30 miles an hour, would correspond to 80 horse power. With a pair of 9 in. cylinders, 15 in. stroke, and four coupled 5 ft. wheels, this resistance would require a mean effective pressure of a little less than 50 lbs. per square inch upon the pistons throughout their strokes, while upon a level the necessary pressure would be less than 25 lbs., and the horse power hardly 40, equal to which a good 12 horse (nominal) portable engine is often made to work. Now, with an ordinary 22 ton engine and tender, weighing in all 35 tons—such an engine as is very commonly employed upon light trains, having, say, 14 in. cylinders, 18 in. stroke, and 5 ft. driving wheels—its own resistance at 30 miles an hour on a level is not less than 720 lbs. requiring 12 lbs. mean effective pressure per square inch upon pistons of nearly twice the area assumed for the steam carriage. The engine and tender, or even the tank engine commonly employed upon light traffic lines weighs, on the average, as much as the train drawn, often, indeed, even more.

It need hardly be said that the resistances of engines and trains have been established by numberless experiments, that the resistance due to any given weight is therefore readily calculable, that it is always in proportion to the weight, and that the cost of working, and especially wear and tear, are in proportion to the resistance. With a given line, then, power can be economized and wear and tear lessened only by keeping down the weight, and why engineers should insist as they do in keeping it up we cannot explain. With the bogie, at each end, the single long carriage can be made much lighter than shorter carriages seating the same number of passengers, each carriage having its two ends, its buffers, etc. The steam carriage we have spoken of runs upon eight wheels, with not more than $3\frac{1}{2}$ or 4 tons each on even the driving wheels, whereas the ordinary "train," to accommodate the same number of passengers, would have from 22 to 26 wheels with a maximum load of at least 5 tons on each driving wheel. The long single carriage would be unquestionably the easier of motion, and it has been demonstrated beyond all question by the experiments at Hatcham that it can be safely backed at twenty miles an hour around curves of no more than 50 ft. radius.

We should be sorry to believe in the truth of the charge, so often made, that railway managers and engineers are disposed to set their faces against all improvements out of which they are likely to make nothing for themselves. But we often regret that the salaries of these officers are not more generally made partly dependent upon the economies which they may effect. As it is, the general manager in the receipt of a fixed salary of from £2,000 to £5,000 a year, and the locomotive superintendent in receipt, according to position, of from £800 to £5,000 (and there is *one* case where the latter sum is paid), do not much care to be bothered. And so shareholders lose, and those who would do them real service are, to employ a serviceable phrase, "left out in the cold." But we have hopes still left, and we must find other reasons, possibly less disinterested to the gentlemen in question, if they persist much longer in willful ignorance of what not only *may be* but actually *has been* done in the direction we have pointed out.

STIFFNESS OF THE ROPE.

Written for Van Nostrand's Magazine by Capt. A. Hill, C. E.

On bending a rope over an axle or a pulley, a certain amount of resistance is encountered. This resistance is called the stiffness of the rope. To ascertain by experiment the amount of this resistance, ropes may be bent around cylinders, which are then allowed to roll on a horizontal plane. The difference in the weights which are suspended on both rope-ends, and which produce a slow rolling motion, will, after subtracting the rolling friction, give the amount of this resistance, or determine what is called the stiffness of the rope.

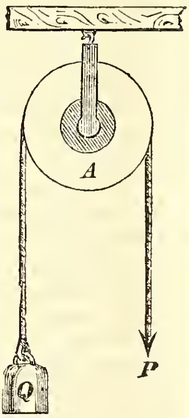
After these experiments, which, however, must not be considered final, the resistance offered through the stiffness of the rope, may be expressed by the formula

$$\delta = \frac{k\,\delta^2}{r} Q,$$

in which Q represents the tension of the rope, r the radius of the cylinder increased by one half the thicknes of the rope, δ the diameter of the rope, and k a co-efficient obtained by experience. For the metric system $k = 18$.

Tarred ropes have always a greater stiffness than untarred ones. Wet ropes, if thin, show a greater, if thick, a less flexibility, other circumstances being equal.

After the previous formula, a rope of two centimeter diameter, bent over a cylinder of four decimeter radius, stretched by a weight of 1,000 kilogrammes, shows a resistance from stiffness of about 18 kilogrammes. A similar result is obtained when a chain is wound round a cylinder. In this case, especially on winding and unwinding, the resistance is occasioned by the friction of the several links. The force necessary to overcome the resistance may approximately be called $\frac{\mu\,\delta}{r}$ Q, in which δ is the diameter of the iron in the links, μ the co-efficient of sliding friction, r the radius of the cylinder increased by one half the diameter of the links, and Q the suspended weight.



Over a fixed pulley A a rope is bent, on the vertical ends of which the forces P and Q are suspended.

How great must P become in order to balance Q and all resistance? Let r be the radius of the pulley increased by one half the diameter of the rope, ς the radius of the pin, δ diameter of the rope, W the weight of the pulley, the rope and the pin, then will

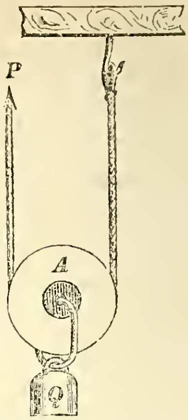
$$P\,r = Q\,(r + k\,\delta^2) + \mu\,\varsigma\,(P + Q + W)$$

whence

$$P = Q\left(\frac{r + k\,\delta^2 + \mu\,\varsigma}{r - \mu\,\varsigma}\right) + W\,\frac{\mu\,\varsigma}{r - \mu\,\varsigma}.$$

Take for example, $r = 0.^m 12$; $\delta = 0,^m 028$; $n = 0.1$; $\varsigma = 0,^m 01$; Q = 200 kil.; W = 5 kil., then will P = 224.24 kil.

Round the movable pulley A, on the pin of which the weight Q is suspended, a rope is bent. How large must the force P become in order to balance Q and all resistance?



Using the same letters for the same quantities, the equation becomes now

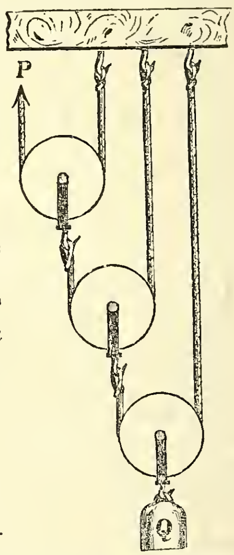
$$P\,r = (r + k\,\delta^2)\,(Q + W - P) + \mu\,\varsigma\,Q,$$

whence

$$P = \frac{r + k\,\delta^2 + \mu\,\varsigma}{2\,r + k\,\delta^2} \times Q + \frac{r + k\,\delta^2}{2\,r + k\,\delta^2} W$$

And substituting the same values as above, we obtain here P = 116.7 kil.

To find P for a system of movable pulleys, when the directions of the rope ends are vertical, and the radii and weights of all the pulleys are equal.



Let ψ, ψ_2, ψ_3 .... ψ_n indicate the tensions of the successive rope ends, and put

$$\frac{r + k\,\delta^2 + \mu\,\varsigma}{2\,r + k\,\delta^2} = a$$

$$\frac{r + k\,\delta^2}{2\,r + k\,\delta^2} = C$$

Then will

$$\psi_1 = a\,Q + C\,W$$

$$\psi_2 = a\,\psi_1 + C\,W = a^2\,Q + C\,W\,(a + 1)$$

$$\psi_3 = a\,\psi_2 + C\,W = a^3\,Q + C\,W\,(a^2 + a + 1)$$

$$\psi_n = a\,\psi_{n-1} + C\,W = a^2\,Q + C\,W\left(\frac{a^n - 1}{a - 1}\right)$$

But

$$P = \psi_n\left(\frac{r + k\,\delta^2 + \mu\,\varsigma}{r - \mu\,\varsigma}\right) + W\left(\frac{\mu\,\varsigma}{r - n\,\varsigma}\right)$$

and making $\left(\frac{r - k\,\delta^2 + \mu\,\varsigma}{r - \mu\,\varsigma}\right) = a'$ and $\frac{(\mu\,\varsigma)}{r - \mu\,\varsigma} = C^1$ we obtain at once

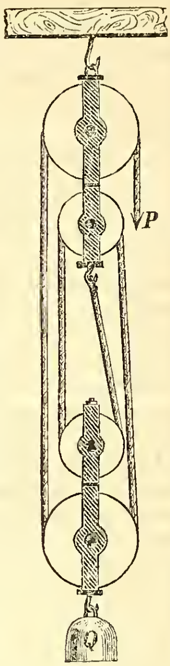
$$P = a'\left(a^n\,Q + C\,W\,\frac{(a^n + 1)}{a - 1}\right\} + C'\,W.$$

Finally, to find P for a system of fixed and movable pulleys, under the supposition that the fixed and movable pulleys are corresponding in size and equal in weight.

Using the same notations as before, we have

$$(a)\ r \times_2 = (r + k\,\delta^2)\,\psi_1 + \mu\,\varsigma\,(\psi_1 + \psi_2 \ldots)$$

in which ψ_1, ψ_2, ψ_3 .... ψ_n represent the successive tensions of the rope, beginning with the fixed end. From (*a*) we obtain



$$\psi_2 = \psi_1 \frac{r + k\delta^2 + \mu\varsigma}{r - \mu\varsigma}$$

or making

$$\frac{r + k\delta^2 + \mu\varsigma}{r + \mu\varsigma} = a$$

$\psi_2 = a\,\psi_1$, and hence
$\psi_3 = a\,\psi_2 = a^2\,\psi,$
$\psi_n = a\,\psi_{n-1} = a^{n-1}\,\psi,$
but $\psi^1 + \psi_2 + \psi_3 + \ldots,$
$\psi_n = Q + W$
in which W equals the weight of the system of movable pulleys.

Substituting in this last equation the values for $\psi_2, \psi_3 \ldots \psi_n$ in terms of ψ_1, we obtain
$\psi_1\,(1 + a + a^2 + \ldots\ldots C^{n-1}) = Q + W$

or $\psi, = Q + W\left(\frac{a - 1}{a^n - 1}\right)$

but since $P = a^n\,\psi_1$. we have

$$P = \frac{a^{n+1} - a^n}{a^n - 1}(Q + W).$$

How to Build.—We read that the builders of ancieut Rome were obliged to warrant their private buildings for ten years, and their public ones for fifteen. Moreover, every accident arising from bad construction during these periods *was to be made good by them or their heirs.* If they were unable to make the necessary repairs, they were whipped, shamed and banished. Some such law like this, if it could be enforced in the nineteenth century, within the bills of mortality of this great city of London, would work a salutary and lasting reform. It is not "how to build," but how not to build; consequently structures are very often, in fact are daily, being erected, whose best recommendation is that they are certain to kill off some portion of every family which may have the misfortune to live in them.

In the first stage of their existence, they effect this by dampness, want of ventilation and the absence of any proper system of drainage. In the second stage of existence of these houses, they kill off their inmates by the presence of too much ventilation. Doors, windows, and roofs exhibit the effects of employing green or unseasoned timber; aching pains begin to trouble the joints and shoulders; and, like the human body, the framing body of joinery creaks with a chronic asthma. In the house where there was insufficient ventilation first, there is any quantity of wind and weather now, for tenon and mortise part company, and paper, lath, and plaster follow suit, with a groan for the internal genii.

The third stage in the life of those model structures is this: that they suddenly drop to the earth with an epileptic spasm, without the least external warning; and in annihilating themselves they bury several families in the one general crash.

Need we add the sequel? Scarcely. We will simply note an "inquest,"—verdict, "accidental death." Not a word of censure on the "jerry builder" or sham contractor, who made a nice thing out of speculating in the blood of his fellow beings. Not a word of reproof on the man that "did not want any of your confounded architects." Not one word on the jack-of-all-trades who was surveyor, engineer, architect, and all. No, not a word. He, like other "lucky dogs," caught up the "tip" of the day, and his trade is to build to *sell*, and not to build to *last.*

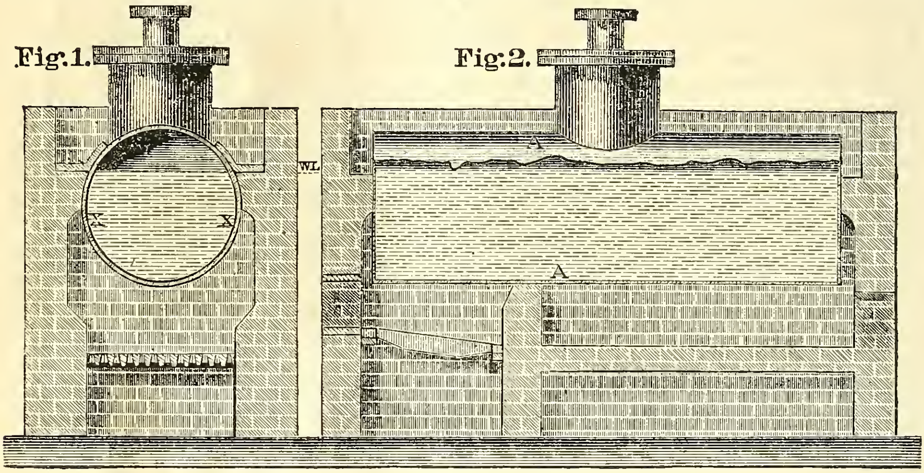
Oh, would that the old Roman law were still in force, or that a vigilance committee were embodied so that the building ghouls of London could be "whipped, shamed and banished" from the country!—*Builder.*

Engine Cranks Cast from Steel.—Messrs. Vickers, Sons & Co., Sheffield, have turned out the second of two of the largest steel cranks ever made, and these cast direct to shape, and not as an ingot.—Its weight, as cast, was 38,500 lbs., or about 17 tons 4 cwt. Five hundred and fifty crucibles were poured, in regular order, in making it. Steel castings have shown surprising and uniform cohesive strength and toughness. They are unquestionably free from any internal flaws or defects of any kind. A cast-steel engine crank, especially of large dimensions, is more likely to be sound (apart from the greater strength of steel *per se*) than a heavy wrought-iron forging of the same shape. Even in wrought-iron forgings presenting no visible or definite flaw, sections cut out and tested have been found to bear no more than 7,000 or 8,000 lbs. per sq. in. The strength of steel, on the contrary, would not vary much from 70,000 lbs.—a strength attended with great toughness or endurance when exposed to sudden shocks.

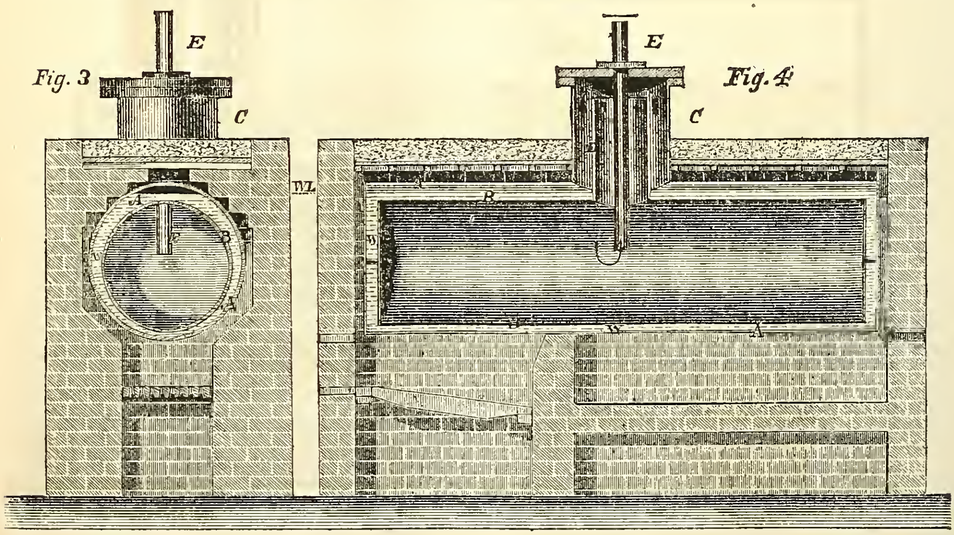
THE GERNER BOILER.

This form of steam generator having now been in actual service for a sufficient time to warrant definite conclusions, and having been subjected to a variety of tests, has developed some notable advantages in working and maintenance, and is attracting a great deal of attention among the users of steam. The accompanying engravings, prepared for this magazine from the latest working drawings adopted, illustrate the different forms of service to which the Gerner principle of construction has been applied. The description and working results are given on the authority of the "Scientific American."

The inventor of this boiler, starting with the assumption that, so far as safety alone is regarded, no form of boiler is superior to the old-fashioned cylinder, has proceeded step by step to develop its steam-producing power without relinquishing its known elements of safety. Figs. 1 and 2 show an end and side view of a plain cylinder boiler, set in brick-work, the space from X to X, around the lower section of the boiler, showing the extent of heating surface. Figs. 3 and 4 give two views of the same boiler, with its power and economy increased by the application of the Gerner Re-inforcement, an application that may be made to any plain cylinder or flue boiler.



Common Cylindrical Boiler.



The Common Cylindrical Boiler with the Gerner Reinforcement attached.

The Gerner Re-inforcement consists in placing within a cylindrical boiler another cylinder of just sufficiently smaller size to leave a space (when set a little out of center) of about 4 in. at the bottom and ends, increasing gradually to about 6 in. at the top. This cylinder, by displacing the large mass of water, as shown in Fig. 2, reduces it to a thin sheet, which fills the space between the two cylinders, and entirely surrounds the inner one; the water line being now near the top instead of the middle of the boiler. The inner cylinder is simply supported at each end by a bracket attached to the outer boiler, and is provided with a dome, open at the top, standing within the dome of the outside cylinder. The steam, as it is generated, rises, as shown by the arrows in Fig. 4, into the outer dome, and thence passes by the inner dome into the interior of the inner cylinder, which thus becomes a large steam reservoir entirely filled with dry steam, which is kept in its normal condition by the jacket of hot water which surrounds and protects it from radiation, the temperature which protects being the same that produced it. The steam-pipe E acts as a steam-trap to convey only dry steam. It will be observed that the pressure of the steam within the reservoir equalizes that of the steam in the water outside, thus obviating the necessity for "staying" and the use of heavy iron in its construction. The water being carried so high in the boiler admits of the brick-work being set off from it, and the fire thus carried entirely around it, throughout its entire length and ends, thereby

Fig. 5.

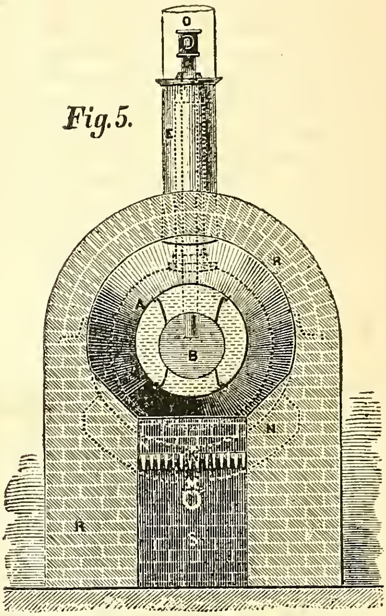
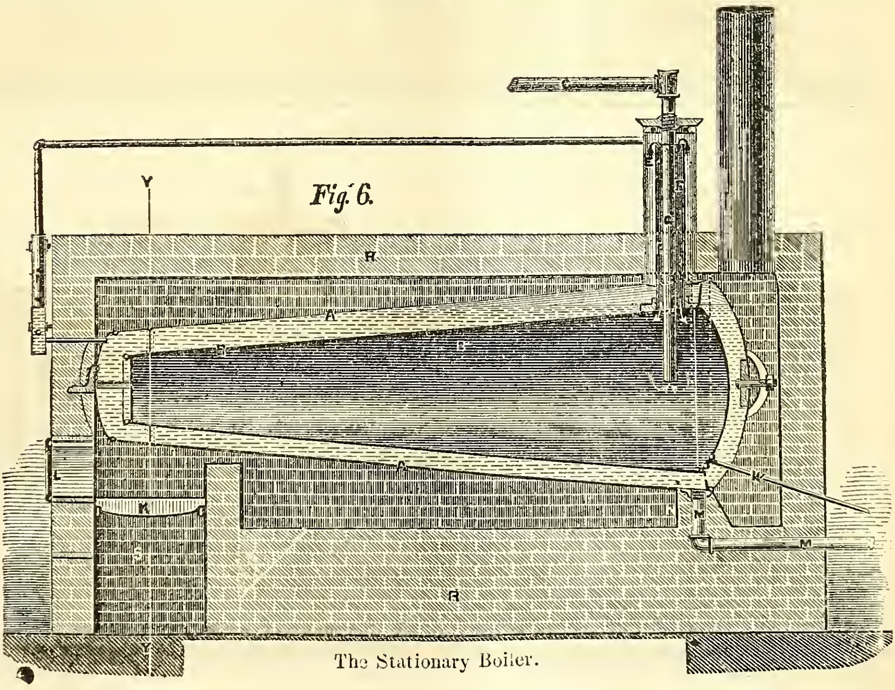


Fig. 6.



The Stationary Boiler.

doubling the extent of heating surface. The brick-work may be thrown in an arch over the boiler, or the successive layers of brick "stepped in" like a reverberatory furnace, as shown in Fig. 3. It should also be observed that the lessened volume of water materially increases the safety of the boiler. C. Wye Williams, in his able work on "Heat and Steam," page 171, asserts that "the risk of explosion is greatly increased by the increase of water in the boiler, every cubic foot of which, beyond what is absolutely necessary for the generation of steam, being an additional source of danger."

The Stationary Boiler.—Figs. 5 and 6 represent the usual form of the Gerner stationary boiler. The shell is cone-shaped, its smaller end being over the grate; the axis is set level. The flame envelopes the boiler, and its escape is checked at the top and sides by a brick partition at the rear, and its exit is through a vent underneath the larger end of the boiler into the flue and chimney. Within the shell is placed a similar cylinder of less dimensions, leaving an annular water space of about 4 in. at the bottom, and 6 in. at the top.

The angle of the heating surface, as here presented to the action of the fire, is best calculated to catch and absorb the heat, impingement being more direct and effective, while the free circulation of the water, from the position in which the conical shells retain it, is greatly promoted. This form also provides an extensive combustion chamber, wherein the gases may become thoroughly ignited, while the rapidly narrowing passage towards the flue, in both the vertical and horizontal direction, so progressively retards the gases in their passage to the outlet, that their combustion is perfected, and their heat, as far as possible, imparted to the boiler. There is no lodgment for refuse, ashes and dirt about the boiler, and all sediment within is naturally deposited at its lowest point, T, whence it is easily blown off. The advantage derived from setting the boiler without contact with the brick-work is great, for when, as is necessary with ordinary boilers, the brick-work and the boiler are brought in contact, any water from the top will settle at the point of contact, become decomposed, and very quickly weaken the boiler by oxidizing the iron. The "Society for the Prevention of Boiler Explosions," in England, report that 50 per cent of the explosions of stationary boilers are clearly traceable to this cause. Unequal expansion and contraction are also, doubtless, as much promoted in a boiler but half bricked in, as in a tubular or locomotive boiler with its varying diameters and position of shell and tubes; for the upper half, exposed to the atmosphere, while the lower part is subject to intense heat, must be unequally affected, and soon lead to the rapid destruction of the boiler.

The Portable Boiler.—This boiler, Figs. 9, 10 and 11, has the form throughout of a locomotive fire-box, with a double shell all over, and open at the back end, the space between the shells being about 3 in. at the bottom, 4 in. at the sides and front end, and 10 or 12 in. at the top. Within this fire-box shaped boiler is placed an exact counterpart of the Gerner stationary boiler. The feed-pipe to both the inner and outer boiler is shown at F F, and the connecting pipe at X. Apart from these two pipes there is no water or steam connection between the two boilers, and with these connections severed, the boilers become in fact two separate steam generators. The inner boiler is supported by a rod in its front end, resting within an expanded tube in the front of the outer boiler, and by two set screws S S, Fig. 11, which pass through lugs in the dome, on to a plate on the outside of the outer boiler. The open end of the outer boiler, after the inner boiler is placed in position, is closed by a cast-iron plate, which arrests the flames after their passage around and underneath the inner boiler, and diverts them into the uptake or chimney. A plate R is placed underneath the inner boiler near the back end, to reduce the size of the escape flue, and to compel the heat to strike the bottom of the boiler in the rear. The water-line in both boilers is the same, and the steam from both is conveyed into the steam reservoir B.

It is a well-known fact that the fire-box of a locomotive boiler is its most effective part, owing to the free development and maintenance of the flame in one mass, not divided by flues, thus illustrating the rule laid down by Sir Humphrey Davy, that "heat communicated by flame depends on its mass." This principle has been still further illustrated by the fact, that the efficiency and economy of many tubular boilers has been greatly increased by lengthening the fire-box and cutting down the length of the tubes. In view of these facts, it is claimed that the outer boiler, above described, furnishes very effective and desira-

Fig. 9

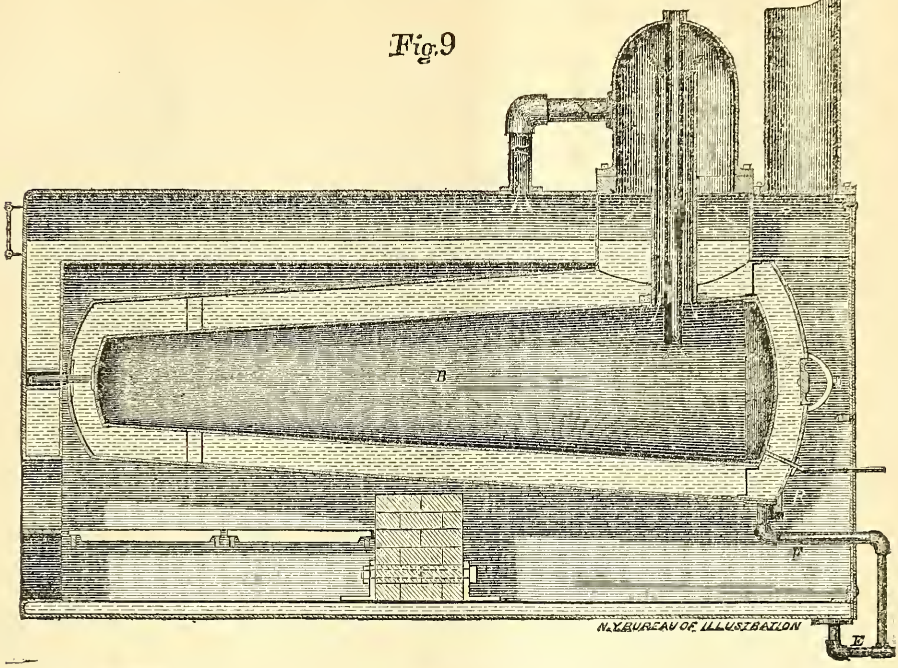


Fig. 11

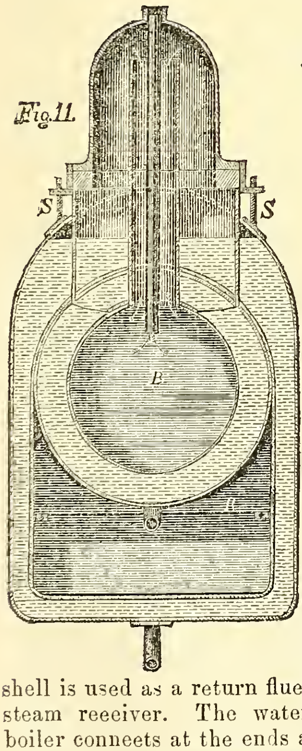
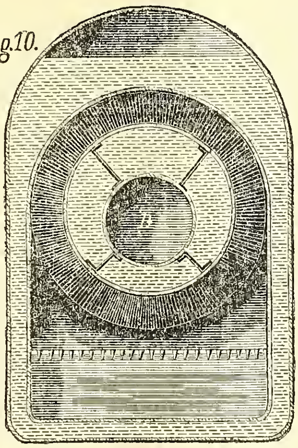


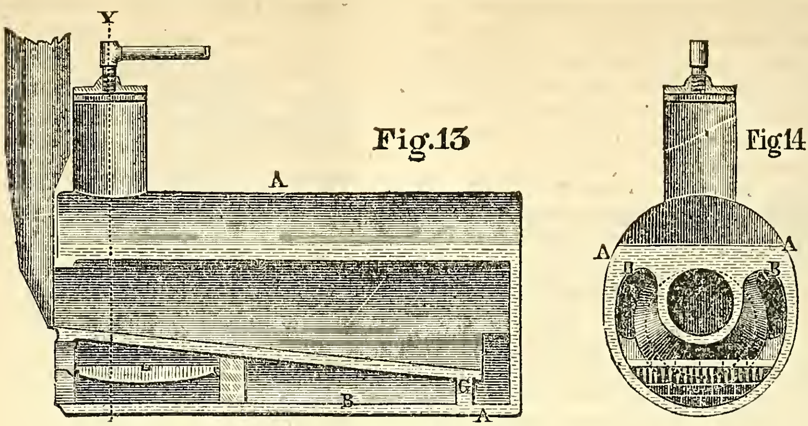
Fig. 10.



able surface for the generation of steam, without presenting any impediment for the free circulation of the water within, or lodgment of ashes or refuse without; and that the inner boiler adds the other advantages of the Gerner principle.

The Marine Boiler.—This boiler, Figs. 13 and 14, may be described as a single return conical flue boiler, forming a conical combustion chamber. Its peculiarity consists in its conical shaped flues and their annular water spaces.

The outer shell A is a plain cylinder, the inner shell B conforms to the shape of the outer shell (forming a space increasing from 4 to 6 in. between the two), to a height somewhat above the center of the boiler, from thence it turns inwardly, and dropping down connects with the outer shell of the double-shelled conical flue. This doubled shelled conical flue traverses the length of the boiler, its smaller end being over the grate bars, and the interior of its inner shell is used as a return flue to the uptake at the front of the boiler, instead of an interior steam receiver. The water space of from 4 to 6 in. between the shells of the outer boiler connects at the ends and on top with those of the doubled shelled flue, which are of the same width, and there is a further connection between the water bottom near its back end, and the water space around the conical flue at its largest end, by the



The Gerner Marine Boiler.

circulating pipe G. The fire-box or furnace portion of the boiler, it will be seen, is very extensive, wherein the flame is maintained in an undivided mass, and the heating surface on all sides presented to its action in a manner best calculated to obtain great efficiency. The gradually narrowing passage towards the opening into the return flue retards the gases of combustion until the greater amount of direct heat is utilized, and after entering the flue, they are still further retarded in their escape to the chimney by the tapering form of the flue, and their entire available heat imparted, as far as possible, to the plates containing thin sheets of water.

Rate of Evaporation.—The authority we have referred to gives, "from actual knowledge," the results of a trial of a Gerner stationary boiler, by the means adopted in the U. S. Navy experiments. The boiler is 10 ft. long, 2 ft. front, and 3 ft. rear diameter, with a grate surface of $4\frac{44}{100}$ sq. ft. The experiments show that the boiler is producing 500 lbs. of dry steam per hour for every 50 lbs. of coal consumed, after setting aside the fraction .65 of a lb. over 10 lbs. of steam produced by the consumption of a pound of anthracite. This margin of 6.5 per cent of the total production will cover many of the defects of unskillful firing. Assuming, then, that in practice the boiler will evaporate 500 lbs. of water per hour with a consumption of 50 lbs. of coal, and allowing 33 lbs. of water to be the fair standard of a horse-power, this boiler is capable of supplying 15 horse-power. The total heating surface being $83\frac{30}{100}$ sq. ft., and the results obtained being over 15 horse-power, shows $5\frac{1}{2}$ sq. ft. in these boilers to be sufficient to produce a horse-power, and illustrates the efficiency of the heating surface.

The test of a marine boiler (*i. e.*, built upon the same plan as one intended for a steam-vessel) now in operation at the New York and Erie R. R. General offices (Grand Opera House), New York, is given by the same authority. The boiler is 16 ft. long, $6\frac{1}{2}$ ft. in diameter, and has produced, according to the testimony of J. W. Brooks, Superintendent of Motive Power N. Y. and E. R. R., 110 horse-power, 3,300 lbs. water evaporated per hour, with an economical result of over 12 lbs. of water to 1 lb. of coal. The entire heating surface being but 400 sq. ft., gives less than 4 sq. ft. to a horse-power.

This result may be better appreciated by taking in comparison a tubular boiler, say $23\frac{1}{2}$ ft. long by 6 ft. in diameter, containing with its tubes a total heating surface of 1,139 sq. ft. Such a boiler, by allowing the ordinary standard of 15 sq. ft. to a horse-power, would be estimated at 75 horse-power, and its steady economical result could hardly be relied upon at over $6\frac{1}{2}$ to 7 pounds water to 1 of coal, with no assurance whatever of the dryness of its steam.

There is no doubt as to the comparative inefficiency of heating surfaces made up of small flues. Various authorities have been quoted in this connection, among others Armstrong (revised by Bourne), who says that "the present construction of the multitubular boiler, as it is called, may be truly stated as a disgrace to the science of this age of progress." C. Wye Williams says: "Heat, communicated by flame, must depend on its mass;" also that "the tubular system is chemically, mechanically, and practically a destroyer of ignition and the sustained existence of flame." Again he says: "The result of the adoption of the multitubular system has been a less perfect combustion, a larger development of opaque smoke, a greater waste of fuel and heat, and a more dangerous application of it."

Various recent experiments within our own knowledge appear to confirm these views. In one small locomotive boiler, for instance, the flues were almost entirely abandoned, and the fire-box was extended nearly the whole length of the boiler with good results. Exact experiments, however, have not been made in this case. The following considerations, at least, will be admitted by all experts: fire-box surfaces are vastly more efficient than flue surfaces. In the multitubular boiler, the flame entering the small tubes is extinguished, combustion of the gases ceases, and a very large proportion of the otherwise available heat pases off in smoke and unconsumed gases, and is lost; free circulation of water is obviously impeded by the multitude of small tubes, and the small inctrstices between them provide a very ready means for the retention of impurities in the water, and consequent incrustation; and, finally, the mechanical difficulty of keeping the tubes tight, in their varing expansions and contractions, is an expensive and dangerous experience to almost all who have used them.

The claim of *economy* made for the Gerner boiler appears, therefore, to be well founded in theory as well as in practice. The *safety* of the cylindrical form, as compared with flat sides, is obvious. The other advantages claimed have been referred to in detail, with the descriptions of the various forms of the boiler. We may add that these boilers are guaranteed for a rate of vaporization in accordance with the results of the experiments above stated.

SAFETY CAR TRUCKS.—Mr. Morris, of the Housatonic Railway, has devised an improvement for relieving the effects of a broken car wheel or rail. He attaches to the truck frame, just inside of the wheels, two stout sled runners, made of heavy plank shod with metal or entirely of metal. In case of running off the track, these runners receive at once the weight of the car, and prevent all but a slight sinking of the wheels. They act as brakes to check the speed and also prevent lateral motion of the car.

COMBUSTION UNDER PRESSURE.

From "Engineering."

We propose to explain briefly what we believe to be the theory of Mr. Bessemer's system of high-pressure furnaces, and show why the fact of the combustion taking place under pressure should cause the intensity of the heat produced to be increased. Fifteen or sixteen years ago, before the question had been settled by the experiments of Regnault, it was considered by many investigators, who either disbelieved or did not perfectly comprehend the dynamical theory of heat, that the specific heat of air and other gases was decreased by an increase in the pressure under which they were confined. We should not have referred to this fact here, but that some recent writers, arguing falsely from the experiments made by Clements and Desormes early in the present century, have endorsed this opinion, and stated that the specific heat of gases decreased as the square root of the pressure to which they were exposed. According to these theorists, the increase of temperature obtained by Mr. Bessemer's high pressure system would be simply due to the fact that the gases generated by combustion being under pressure, had a less specific heat than those escaping from an ordinary furnace fire, and that consequently a given quantity of heat was capable of raising them to a higher temperature than could be obtained under ordinary circumstances. The admirable experiments of Regnault, however, described by him in the "Comptes Rendus" for 1853, conclusively proved that the specific heat of air was sensibly constant at all pressures and temperatures at which it was tested, and the explanation we have just mentioned is therefore an untenable one. We shall now proceed to state what we believe to be the true explanation of the results obtained by Mr. Bessemer, these results being, we consider, fully accounted for by the dynamical theory of heat.

It was long ago shown by Poisson and Laplace that the quantity of heat required to raise the temperature of a given weight of any gas, a certain number of degrees, is less if that gas was maintained at a constant volume, than if it is allowed to expand freely during the heating process. In other words, the specific heat of a gas maintained at a constant volume is less than that of the same gas maintained at a constant pressure, the difference in the two specific heats under the two circumstances being due to the heat absorbed in performing the work of expansion. In the case of air the two specific heats have been ascertained to be .169 and .238 respectively (that of water being denoted by 1), and it thus appears that a pound of air in expanding to the extent due to a rise of temperature of 1°, absorbs, or renders latent, .238—.169 = .069 of a unit of heat. It is to this fact that the heating of air which takes place under compression is due, for when a quantity of air is reduced in bulk, the heat which had been previously employed in maintaining it in an expanded state becomes re-converted into sensible heat, and the temperature of the air is raised accordingly. It will thus be seen that the compression of the air does not increase the quantity of heat contained in it, but merely renders sensible a portion which was previously latent, and it follows, therefore, that a certain weight of air or gases containing a given quantity of heat will have a higher temperature if compressed than if maintained at ordinary atmospheric pressure.

In Mr. Bessemer's high-pressure furnaces the gaseous products of combustion are, it is true, not allowed to expand and then heated by compression, but they are prevented from expanding as they would do in an ordinary furnace, and, as far as the results go, the effect is the same. In other words, in a high-pressure furnace working at a pressure of, say, two atmospheres, the temperature of the gaseous products of combustion is the same as if they had been allowed to expand under ordinary atmospheric pressure, and then suddenly compressed until the pressure became doubled. Now it can be shown by reasoning founded on the data we have given, that what is known as the *absolute* temperature — or the temperature in degrees Fahrenheit + 461.2°—of any given quantity of air will, if that air be compressed, vary as the .29th power* of its pressure above a vacuum ; or, in other words, if T_1 = absolute temperature of a certain quantity of air under a pressure P_1, its temperature, T_2, under another pressure, P_2, will equal $T_1 \times \left(\frac{P_2}{P_1}\right)^{.29}$. If now we assume, as we probably may do without any sensible error, that this formula for air is applicable to the gaseous products of combustion obtained in a high-pressure furnace, we shall be in a position to calculate the increase of temperature due to the adoption of the high-pressure system in any particular case. Perhaps an example or two may render this clearer.

Let us suppose, for instance, the case of a furnace in which the proportions of carbonic acid and carbonic oxide produced by the combustion of the fuel are as one to four, and let this furnace be worked, in the first instance, under ordinary atmospheric pressure. Now, we showed in the early part of the article, in our number for the 17th ult., to which we have already referred, that when carbon is supplied with just sufficient air for combustion, and is burnt into carbonic acid, the highest temperature theoretically obtainable is about 4,500°, while if it is burnt into carbonic oxide, the temperature will be about 2,250° only. In the case we are now considering, therefore, supposing that there is no loss of heat from radiation or the admission of excess of air, etc., the most intense heat attainable will be $\frac{(2,250 \times 4)+4,500}{5} = 2,700°$ above the temperature of the air and fuel introduced into the furnace. If, now, the temperature at which the materials are introduced be taken as 60°, the temperature of the products of combustion under the above circumstances will be 2,760°, and their *absolute* temperature 2,760 + 461.2 = 3,221.2°. Let us next suppose that the furnace is worked at a pressure of 15 lbs. per sq. in. above the atmosphere, or, say, at a pressure of two atmospheres, the products of combustion being the same as before. In this case the *absolute* temperature of the products instead of being 3,221.2°, will be $3,221.2 \times 2^{.29} = 3,221.2 \times 1.222 = 3,936.3°$, and their temperature expressed in the ordinary way will be 3,936.3—461.2 = 3,475.1, or, say, 3,475°, being a temperature 715° higher than that obtained in a furnace worked at atmospheric pressure. In the same way we should expect to find that if the pressure under which the furnace is worked is increased to three atmospheres, the temperature of the products of combustion will rise to $(3,221.2 \times 3^{.29}) - 461.2 = (3,221 \times 1.375) - 461.2 = 3,967.9°$, or, say, 3,968°, a temperature more than 1,200° in excess of that obtainable under ordinary circumstances.

It will, of course, be understood that the temperatures above given are merely rela-

* The .29th power of any number may be readily obtained by the use of a table of logarithms.

tive, being illustrative of the effects due to the high-pressure system of working as compared with what we may call, for distinction, the ordinary low-pressure system. In practice the actual temperatures obtained will depend not only upon the pressure used, but also, for the reasons we have already explained in our former article, upon the completeness of the conversion of the carbon of the fuel into carbonic acid, and upon the manner in which the supply of air is adjusted, as well as upon the means adopted to prevent loss of heat. Mr. Bessemer is, we understand, about to try a series of experiments on a furnace worked at various pressures, and we look forward with much interest to the results of these experiments, which we shall be glad to know agree with the theory we have advanced.

Transmission of Power by Wire Ropes.—There are, at Moulins Galant, near Corbeil, 22 miles south of Paris, some important paper mills belonging to MM. Darblay and Company. One of these mills is worked by an hydraulic wheel of about 30 horse-power. But the power of this wheel not being sufficient all the year round, it was necessary to provide a supplementary power, which has been obtained from another fall on the same river, 770 yards up the valley. This fall, of about 40 or 45 horse-power, was formerly, and is even now, used for working a flour mill, which has been taken on lease by M. Darblay. The connection between the flour mill and the paper mill has been made with a telodynamic* wire. This system of transmission consists of an iron endless wire supported by pulleys, and running at a very great speed. It is thus possible to transmit a large power through a very thin wire, and this system is now extensively used in France, especially in the eastern districts. The Moulins Galant wire is worth notice, because, besides its great length, the axles of the driving and driven pulleys are neither parallel nor situated at the same level. The angle between these axles is 8 deg. 10 min., and the driving axle is 14 ft. 1 in. above the other; both are, of course, horizontal. The wire has been arranged in a polygonal line, and at each summit of this polygonal line there are two pulleys, bearing the driving and the driven wire. It was necessary to give to the axles of these pulleys such an inclination that the plan of the pulley should include the tangents to the two adjoining curves of the wire by each side of the pulley. The shape of these curves, and the inclination of their tangent, had accordingly to be calculated with the greatest care; and the pulleys had afterwards to be accurately arranged in the calculated situation. Any mistake in these calculations would produce a great waste of power, and sometimes would enable the wire to get out of the grooves of the pulleys. All this plant has been successfully arranged by MM. Callon and Vigreux, civil engineers, and it has worked quite well for nearly eight months. The diameter of the rope is $\frac{1}{2}$ in., it weighs 9 lbs. per yard, and it consists of 48 iron wires $\frac{1}{24}$ in. diameter, and of a central hemp strand of about $\frac{1}{4}$ in. diameter. The speed of the rope is 61 ft. 9 in. per minute, and the calculated strain is 666 lbs. on the driving, and 313 lbs. on the driven wire. The diameter of the driving and driven pulleys is 8 ft., and they have an angular speed of 150 revolutions per minute. The hydraulic wheel running only $3\frac{1}{2}$ revolutions per minute, the proper speed is given to the driving pulley through two intermediate wrought-iron shafts, supplied with cast-iron spur-wheels. The wire is supported by seven intermediate pulleys, 6 ft. 6 in. diameter, and there is an average span of 246 ft. between these pulleys. There are some masonry piers, 10 ft. to 20 ft. high, carrying these pulleys, and supplied with wrought-iron ladders for oiling the journals. The average deflection of the wire between the pulleys is 10 ft. for the driven and 5 ft. for the driving wire. This latter runs very near the ground in some places through the meadows. The inclination on the horizontal of the shafts of the pulleys is 4 deg. 8 min. for the driven, and 8 deg. 28 min. for the driving wire. It is also necessary to calculate very accurately the total length of the rope; upon the length depends the tension; with a too great length the wire could be allowed to slip in spite of the leather lining of the grooves of the pulleys; with too short a wire the friction would be uselessly increased; in both cases the wire would be liable to fall down the pulleys. This dangerous accident happened once at Moulins Galant, the wire being pulled by a hay cart crossing under it, but nobody was injured. The calculated slack of the wire is about 20 ft., and this length has been ascertained to answer quite well. There is

* From the Greek τηλε far, and δυναμις power.

a telegraphic connection between the two mills in order to stop the wheel when there is some accident to the paper mill. The flour mill is of course kept at work when there is in the river a sufficient flow of water, and when all the requirements of the paper mill are performed. The waste of power by friction is about one-sixth of the total power. The wire is without any connection with the paper engine of the paper mill, which is worked by a small steam engine.

It must be remembered that when such ropes are worked in connection with a steam engine, this latter wants a very powerful quickly acting governor, in order to prevent the overrunning of the engine, should the wire suddenly break down. Such an accident happened, some years ago, in a cotton-spinning works in Alsace, and a large steam engine was entirely destroyed.—*Cor. The Engineer.*

COIGNET'S ARTIFICIAL STONE.

From "Engineering."

For about twelve years the "Béton aggloméré" of M. F. Coignet has been employed in France, at first sparingly, and with hesitation, but of late so largely and with so much confidence, that many of the large works in and near Paris have been constructed for the most part, or entirely, with this material.

So early as 1850, M. Coignet had experimented further than his predecessors Fleuret (1800) and Lebrun (1829), but the conglomerate he then produced was unsatisfactory. In the commencement he employed a crude mixture of coal cinder with lime, and subsequently he substituted sand for the former ingredient, and mixed it with powdered lime, moistening both together instead of wetting the lime as he at first done. The second process to which he arrived, after modification and a long series of experiments with materials from different districts, and under varying circumstances, to ascertain the best proportions, is the system which has now grown into such a vast industry, and which bears his name.

The béton Coignet is a mixture of a large proportion of sand with a small proportion of lime, to which is added a percentage of cement varying with the amount of hardness or the rapidity of setting required. Only a very small quantity of water is employed to moisten the lime and sand. Thus tempered the mass is reduced, in a grinding mill, to a stiff paste, and is introduced into moulds of any desired form, being then subjected to the action of repeated and heavy blows. By this means it is thoroughly agglomerated, and the mould being almost immediately removed, the béton, shaped to the desired figure, shortly becomes set, and acquires the hardness of stone.

The material thus mixed and compressed under the hammer, when placed in the mould, receives a weight, strength, and density which renders it a thoroughly trust-worthy building material. On the average 1.31 bushels of component parts, sand, lime and cement, make a cubic foot of béton which will weigh about 140 lbs., and offer a resistance of some $2\frac{1}{2}$ tons per square inch, while ordinary mortar, formed of the same constituents, will exhibit very insignificant powers of resistance. The difference arises principally from the difference in manipulation; in mixing mortar an excess of water is always used, which is distributed throughout the mass, and separates the particles of lime and sand, retarding the setting, and when after a time the water evaporates, it leaves the mortar more or less porous.

Theoretically, the Coignet process fills all the necessary conditions, and produces a perfect béton, the sand and lime being moistened with a minimum of water, and mingled as intimately as possible. Besides the thorough cohesion of the particles induced by the mixing and compression, the small quantity of water used makes the setting more rapid and more uniform.

In all cases the lime used should be hydraulic, in fine powder, and well screened, to free it from lumps; for if there are any lumps admitted into the béton they swell when the mixture is diluted, and weaken the material.

The cements used are always, if possible, heavy and slow setting. The quantity used is proportioned to the rapidity of setting required, and the hardness of stone which it is sought to obtain. For the third ingredient, river sand, mingled with small pebbles, is the best. If the pebbles are large, the concrete produced is rough and unsightly; if it is too fine, it retards the setting, and reduces the hardness. Pit sand will make very good work, but to produce a stone so good as that formed on a base of river sand, the proportions of cement and lime have to be increased. Very fine sands like those of the Landes, require very careful mixing and a prolonged compression in the mould to produce a first-class béton.

The ingredients are measured into a mixing mill in barrows, and during the process small quantities of water are gradually added as the mixing proceeds, until the béton becomes in the necessary condition; the more completely this part of the work is done the more rapid will be the setting, and the harder will the stone become.

The ordinary form of grinding mill employed consists of an iron cistern, the bottom of which is perforated, and in the center of which revolves a vertical shaft, armed with a number of helical knives, and carrying beneath it a cycloidal arm, which in each revolution discharges a part of the paste. A penstock covering the outlet regulates the discharge of the béton. The material thus obtained from the mill is in a firm but plastic state, and it is thrown into a mould, in thin layers, and each layer, as it is laid in, is beaten and compressed by the regular and even blow of a sixteen pound hammer. In order to secure a perfect adhesion and union of the different layers of material, especially when fine sand is used, it is generally the custom to cross cut the surface of the layer in order that the superincumbent thickness may be thoroughly united to it.

There are two kinds of moulding to which the Coignet béton is applied, the first being used when the material is employed *en masse* in place, the second when it is moulded in blocks to be subsequently employed. The moulds which are intended to be used in place are composed of close boarding kept in place by means of cross bracing. This mould carries the ornaments which are destined to appear upon the face of the structure after completion. In the second class of work all kinds of ornament can be produced from cornices to statuary.

Of late years the application of the Coignet béton has been equally extensive and varied. In Egypt, where it has been employed on a vast scale, light-houses have been reared out of the almost impalpable sands of the Isthmus of Suez. In Paris, some 40 miles of sewers have been constructed of the same material; and arches of the basement buildings of the Exhibition of 1867, saw mills at Aubervilliers, the numerous cellers of many private houses, entire buildings of five and six stories in height, railway bridges at Sainte Colombe, on the Paris, Lyons, and Mediterranean line, a church at Vérinet, and above all the large works connected with the new Paris water supply, and some examples of which we illustrate on another page.

The exact proportion of materials employed on works of different classes, and with sand and lime produced from different districts, will be interesting. Thus the work about the Exhibition of 1867 was formed of a mixture by bulk of 5 of sand, 1 of lime, and $\frac{1}{4}$ of cement. The same proportion holds good for the sewers, and the rapidity of setting is as great, that the centering can be struck within ten hours after the béton is got in place, and the sewers can be put into service in four or five days after their completion. Arches, of which the rise is one-tenth of the span, are generally made with a mixture of 5 of sand to 1 of lime, and $\frac{1}{2}$ of cement in bulk.

The church at Vérinet is one of the most interesting of the monolithic structures, and was constructed of sand from pits at Vérinet. The mixture was 5 of sand to 1 of lime and $\frac{1}{4}$ of cement. In the saw mill of Aubervilliers, the arches are 27 ft. 10 in. in span and $13\frac{3}{4}$ ft. thick at the crown, the proportions are also 5, and 1, and $\frac{1}{2}$ of cement. One of the most generally useful applications of this material is in the construction of the basements of houses. In the ordinary form of construction, stone piers, supporting rubble masonary arches, are employed, involving numberless joints, and causing an absence of perfect uniformity. From this cause numerous settlements ensue, which are avoided by the use of the homogeneous béton; for the whole sub-structure can be made in one single block, over which the superincumbent load is equally distributed, and a uniform pressure upon the foundation is obtained. One house, in the Rue de Miromesnil, is constructed entirely of béton, and it contains two staircases, the one formed in the usual way, with a number of moulded blocks, the other a spiral staircase, from basement to garret—a monolith.

Aqueducts are now being constructed from this stone upon the works for the supply of Paris with water from the Vanne. Already a part of the city draws its supply from the Dhuys, but the second portion of the system is not yet complete. The distance of Paris from the source of the Vanne is more than 94 miles, and in its course to the city the line has to traverse a series of valleys and ravines, to cross rivers, roads and railways, and the numerous requirements of the works have involved the formation of extensive bridges, aqueducts, syphons, and tunnels. An immense reservoir will be completed close to the park of Montsouris, and a long aqueduct upon arches will be made almost close to the old Roman aqueduct of Arcueil. But the heaviest works upon the undertaking are those crossing the valley of Fontainebleau for a distance of more than twenty-five miles between the river Loing and the river Essones. This length almost entirely, without building materials, would have involved very costly works if masonry had been employed, and the engineer-in-chief, M. Belgrand, has therefore availed himself of the Coignet process, and utilizing the vast masses of sand that lay ready to his hand, has formed the work of béton. Not only have the aqueducts been constructed of this material, but the tunnels also to the extent of several miles, about 6 ft. 6 in. in diameter and 8⅝ in. thick, and these were all formed with the same success that has attended the application of the system to the sewers of Paris, the centres having been withdrawn almost immediately after the béton had been rammed into place. The aqueducts crossing the valley are supported upon arches, extremely light, and rising to a maximum height of 50 ft. from the ground. The openings are about 42 ft. 6 in., and the thickness at the crown 15¾ in. The success which attended the application of this material in the construction of the narrow openings supporting the aqueduct, induced the engineer to extend its use to those wider arches spanning rivers, roads, and railways, and, a series of experiments having proved highly successful, monolithic structures, of 98 ft. 6 in. and 115 ft. 9 in. openings, and with one-sixth rise, were rapidly formed.

It will thus be seen that while we have refrained from experimenting (with one exception) in this method of construction, French engineers have advanced to recognize its value, and to employ it largely for a variety of work, having tested its reliability by a series of exhaustive trials. The single exception to which we refer is the concrete bridge constructed by Mr. Fowler across the Metropolitan Railway at Kensington, but even that experiment was scarcely analogous, for the material employed was simyly concrete, mixed with cement it is true, but mixed in the ordinary way, and thrown into the mould instead of being carefully set in the layers and well combined, as in the Coignet process. But the extensive adoption of concrete structures in France will probably be followed by an equally extended adoption of the system here.

BLAST-FURNACE BLOWING-ENGINES.

Translated from a paper read by Mr. SCHMAHEL, before the Upper Silesian Society of Engineers.

The Upper Silesian Society of Engineers had, in a former meeting, proposed the following questions:

Which blowing-engines are preferable, those with upright, or those with horizontal cylinders? and what are the reasons why the one or the other of these constructions is preferable? Is it advantageous to use two or more small blowing-engines in the place of a single large one?

These questions may be answered in the following manner: Horizontal blowing-engines are mostly high-pressure engines. They are not expensive, easily accessible, simple in their arrangement, and can be safely founded on almost any kind of ground. The clearance in the air-cylinders is very small. On the other hand they do not allow of a very long stroke; their piston-rods are liable to be bent, and the pistons as well as the piston-rods are worn-out unevenly, thereby causing loses of blast from leakage. They require a large surface of ground, and use a considerable quantity of lubricating materials.

Vertical blowing-engines may be constructed with beam and fly-wheel, or direct acting without fly-wheel. The former are preferable.

When compared to the horizontal engines, the vertical engines with fly-wheel have the following advantages:

1. They require less room.
2. They can be constructed with a longer stroke, which tends to diminish the loss of blast.
3. The wear of the pistons, cylinders, and stuffing-boxes is smaller.
4. The piston-rods can be guided in a more perfect manner, and thus be prevented from bending.

These engines are, however, much more expensive than those with horizontal cylinders, because they have to have a beam, and a greater number and more complicated connecting parts. They also require stronger foundations for the cylinders as well as for the stands which support the beam.

Wherever the cost was considered an important point, and where sufficient room was available, the horizontal engines have formerly been generally preferred. Of late, however, new blowing-engines for blast-furnaces are mostly constructed with beam, fly-wheel and upright cylinders. Vertical and direct acting blowing-engines, without fly-wheel, do not work economically when two or more such engines have to work together, as is mostly the case. For it is then to be feared that from an accidental stoppage of one of them, the pressure of the blast on the pistons of the others would be so suddenly diminished that too violent a motion might take place which would produce the breakage of the cylinder-covers, of the pistons, of the piston-rods, of the counter-balance, or of other parts of the mechanism. To prevent such accidents the cylinders must be made longer than the stroke. This causes a considerable waste in clearances, loss of blast, and a diminution of the working effect of the engine.

I had, recently, the opportunity of inspecting a great number of blowing-engines at different German iron works.

The horizontal engines I saw had blowing eylinders of 5 to 8 ft. in diameter, and 4 to 8 ft. stroke, working at a speed of 72 to 150 ft. per minute. On all these engines, with but a few exceptions, I noticed the bending of the piston-rods. Amongst the larger engines of modern construction, which I inspected, but two were free from this defect. They had hollow cast-iron piston-rods of 9 to 10 in. diameter, resting on slides 15 in. wide and 18 in. long. The pistons were made of iron-plate. The engines made 10 to 12 revolutions per minute, which number could however be increased to 20 without any trouble or danger.

A wear of the lower part of the piston-rods was not perceptible, owing to the large surface of the slides. All the vertical engines I met with were beam-engines with fly-wheel. The smallest cylinder of this kind of engines had $5\frac{1}{2}$, the largest 10 ft. diameter. The shortest stroke was $7\frac{3}{4}$, the longest stroke 9 ft. The speed varied from 144 to 288 ft. per minute. It is seen from these numbers, when compared with those mentioned before, that the vertical beam-engines can be built of larger size and more powerful and effective than those with horizontal cylinders.

As to the question whether two or more smaller engines are preferable to a single large one, it may be said that smaller engines are preferable when more than one blast-furnace has to be worked. The running expenses are more considerable, it is true. But the losses of time and work, caused by stoppage for repairs of the engine, will amount to a much higher sum, when two or more blast-furnaces are dependent on a single blowing-engine. S.

IRON AND STEEL NOTES.

Fettling or Lining Puddling Furnaces.—In the ordinary method of fettling or lining the beds and sides of puddling furnaces oxide of iron or a compound consisting mainly of oxide of iron is employed for that purpose. An invention patented by Mr. W. M. Williams, of Sheffield, consists in lining puddling furnaces with crude or prepared oxide of manganese or manganese ore, either as the chief ingredient of the fettling or as an addition to the oxide of iron or other material, which is employed. In using crude or native oxide of manganese or manganese ore without admixture with other solid, an ore is used which when pulverized and moistened will form a plastic or pasty mass, and which when heated will harden and adhere firmly to the sides and bottom of the puddling furnace. For this purpose the cheap oxides containing a considerable proportion of iron are best suited, provided they do not also contain other impurities, such as sulphur and phosphorus which would injure the iron in the furnace. When an ore or prepared oxide is used which does not harden sufficiently, after being rendered plastic by water alone, it is mixed with a sufficient quantity of finely powdered and moistened hematite or other suitable material to give it the property of hardening and adhering when heated in the furnace.

The proportions in which oxide of manganese and oxide of iron should be mixed in order to make the fettling according to this invention, vary with the nature of the cast or pig iron to be puddled. With pig iron of ordinary quality about half a hundred weight of oxide of manganese mixed with the requisite quantity of oxide of iron for the fettling of the furnace is sufficient for a charge of four to five hundred weight of pig iron. When the pig iron itself is rich in manganese a less proportion is necessary in the fettling. When the pig iron contains a large quantity of silicon and little manganese, more oxid of manganese is required in the fettling than is required with pig iron containing much oxide of manganese and little silicon. Where practicable, the inventor prefers to introduce the pig iron into the puddling furnace in a melted state; when this is done and the fettling containing oxide of manganese is laid on the bottom and lower part of the sides of the furnace, the charge gets the full benefit of the evolution of oxygen, which takes place when the oxide of manganese is heated. By the use of oxide of manganese, as described, the puddling process is expedited, and the quality of the iron or steel produced is improved. The heated iron or steel during the puddling process decomposes the oxide of manganese, causing an evolution of oxygen, which rising through the molten iron or steel rapidly oxidizes the oxidizable materials contained in the metal. A portion of the reduced manganese enters into alloy with the iron or steel and effects the improvement in the quality of the metal which is well known to result from the use of manganese in the manufacture of iron or steel.

When oxide of manganese is mixed directly with the charge for fluxing, as has been proposed, a portion is liable to become mechanically distributed through the mass of iron ot steel in the state of an infusible powder, consisting of manganese in a low state of oxidation, and injures the mechanical properties of the metal. But when oxide of manganese is used in the fettling of the puddling furnace, according to this invention, it is gradually decomposed as the carbon and silicon of the pig iron or steel are presented to it by the stirring of the puddler, and the manganese enters the charge in a fused state either as reduced metal or as silicate.

Very little of the manganese which enters the iron or steel during the puddling process remains in the finished metal, most of the manganese separating during the finishing of the metal in the form of silicate of manganese, carrying with it other impurities, such as phosphorus and sulphur. The silicate of manganese separates from the metal more readily than silicate of iron, and is found in considerable quantity in the cinder and hammer slag. The cinder and hammer slag are therefore more valuable than ordinary cinder or hammer slag for the making of cinder iron in consequence of their richness in manganese. Although the fluxing property of oxide of manganese, either alone or mixed with oxide of iron, renders the addition of any other material to the fettling unnecessary when pig iron or steel of the ordinary qualities are puddled, yet when pig iron or steel of such quality as renders the use of alkaline fluxes desirable is about to be puddled, common salt or carbonate or nitrate of soda may be added to the oxide of manganese. A quantity of the soda salt equal to about one-fourth the weight of the oxide of manganese is generally sufficient.—*Mechanics Magazine.*

Mons. C. Schinz on Messrs. Ponsard and Boyenval's Improvements in the Manufacture of Iron.—To aim at obtaining wrought iron directly from the ores appears to be, at first sight, the most legitimate course which the inventions on the subject of iron production could take. Yet, as a matter of experience, it is plain that unless we have to deal with exceptionally rich ores, the proceeding is far from being an economical one. This becomes more apparent when we take into consideration the measures which from time to time, and up to the present day, have been adopted or proposed in carrying out this scheme. Neither Clay, in 1837, nor his successors, Renton, Chanot, Yates, Gurit, Rager, Siemens, and recently Ponsard and F. F. Boyenval, have succeeded in solving the problem satisfactorily. With or without the use of the blast-furnace, the oxide or peroxide of iron has first to be reduced in the ores. We have on a former occasion given a lengthy description of M. Schinz's labors on the subject of blast furnaces, and must refer our readers to those columns for the better understanding of M. Schinz's position regarding the subject before us. M Ponsard himself has lately ("Comptes Rendus," p. 177) laid his views before the Academy at Paris. He starts from the fact that the fuel used in the blast-furnace is excessive, and far beyond what is required "theoretically" for the reduction of the ores, the carbonizing of the iron, and the smelting of the pile. He proposes a separation of the chemically acting carbon from that which is consumed for heating purposes, and goes on to assert that but 1,000 kilogrammes of coal, instead of 3,000, as ordinarily used per ton, are needed according to his plan. M. Schinz says that Ponsard and Boyenval's patent is not much more than the ordinary test process of the laboratory on a larger scale; the only difference being that, whereas in the ordinary trials a surplus of carbon and scoriæ is added, he, M. Ponsard, used merely the exact quantity requisite for carbonising and smelting. This process, however, is the same as that going on in the hearth of the blast-furnace when the ores arrive there unreduced. The peroxide of iron (or sometimes the oxide) is reduced by the contact with solid carbon. This reduction, however, is not confined to the oxides of iron alone; other substances contained in the scoriæ are effected in the same manner and yielding sulphur, phosphorus, silicium, &c., which are by no means desirable companions for the produced article. In the blast-furnace, hot air and an insufficient supply of scoriæ generally produce this bad effect partly; while Ponsard's apparatus is so arranged as to have it throughout. The resulting inferior material will have to be refined, and, in that case, the inventors can hardly claim to have saved anything by their so called direct production.—*The Engineer.*

Lurmann's Blast Furnace.—A considerable number of German ironmasters have, during the last two years, applied to their furnaces the system of Mr. Lürmann, the manager of the Georg-Marien Mining and Iron Company, of Osnabrück, Prussia, the improvement consisting in closing the front of the hearth, thereby dispensing with the dam stone, tymp, &c. A scoria outlet is set in the closed breast at a distance of about 6 in. below the tuyeres, and through this outlet the slag runs off regularly and constantly. The tapping hole is placed where the heat is greatest.

This arrangement has been successfully worked for six months or more at the Old Park Ironworks, Shropshire, and more than one of our leading ironmasters have expressed their intention of adopting it. Its advantages are thus enumerated:

1. The slag discharges itself through the scoria outlet at about the same level, therefore there are no vacillations of the slag in the hearth, and the corroding of the wall is diminished.

2. As there is no fore-hearth, there are of course no repairs, and no breaking up of the scoria-crust in the same. This is equal, as shown above, to a saving of at least 20 days per year. Suppose a large furnace produces 40 tons per day, the same will yield at least 800 tons per year more, if built on Mr. Lürmann's principle, than if it were of the ordinaay construction.

3. As there are no interruptions, the furnace does not cool. It works more regular, as the heat in the furnace is always the same.

4. The doing away with the dam and the fore-hearth allows the removal of the tapping-hole from the former into the wall of the hearth. The opening of the tapping-hole is then easy, as it is close to the greatest heat.

5. The completely closed earth allows a con-

siderable increase of the pressure of the blast, because a throwing out of materials has become impossible.

6. The increase of the pressure is always of great importance, but especially where pit coal, anthracite, &c., are used; and where the layers are compact. The number of charges can be greater, effecting a corresponding increase of produce.

7. The augmentation in the number of tuyeres, and the equal distribution of them, made feasible by the doing away with the forepart of the hearth, allow a better and equal distribution of the blast in the hearth; the furnace therefore works better, and a greater quantity of ore is smelted, provided there is sufficient blast.

8. The number of hands may be lessened, as the operations are few and easy; the same need not be of great skill and experience. No fire clay and other refractory materials for the repairs, and less tools are wanted. It may be mentioned that formerly the smelters of Georg-Marien-Hütte, when working, were almost stripped; now they are always in full working dress.—*The Engineer*.

The Cambria Iron Works.—The largest iron works in the country are the Cambria Works, at Johnstown, Pa. They cover an area of about five acres, run night and day, and give employment to about 3,000 hands. They contain 42 double furnaces, over each of which is a steam boiler connected with the engine. The engine is a vertical one of 350 horse-power; its fly-wheel is $30\frac{1}{2}$ ft. in diameter, and weighs 56 tons. The capacity of the works is 1,400 tons of railroad iron per week. Last year they turned out 76,000 tons, and this year expect to produce 82,000.—*Am. Artizan.*

The engine referred to is that of the new puddle train, a three high train 5 rolls long, with two squeezers. There are besides, another puddle train, two rail trains and various small trains, each with its engine. The Bessemer Steel Works of the Company, adjoining the iron works, and capable of producing 50 tons of ingots per day, are also nearly completed.—Ed. V. N. M

Steel Rails and their use in America.—We quote the following from a comprehensive article in the New York "Tribune": The report of the exhaustive and important discussion held last year by the Institution of Civil Engineers in England, sums up the case in these words: "There can be no doubt as to the expediency of employing steel rails, even on railways where the traffic is light; but, of course, the heavier the traffic the greater will be the economy of substituting steel for iron."

In view of this forcible verdict in favor of steel rails, it becomes a matter of great public interest to know to what extent these rails are being laid in the United States. The report on railroads of the State Engineer and Surveyor of New York, prepared by S. H. Sweet, Deputy, and copied from the advance sheets, into "Van Nostrand's Eclectic Engineering Magazine" for last June, says: "It is estimated that from 40,000 to 50,000 tons of steel rails are in use on our various railways." Careful researches, made in this city during the past week, warrant the use of much more encouraging figures, and authorize the assertion that by the end of the year 1869 there will be laid in the United States, in round numbers, 110,000 *tons of steel rails*, equal to 1,100 miles of steel road; and of this amount about 36,000 tons, equal to 360 miles, will be laid during the present season! These rails are in use on more than 50 different roads, and are partly of American, principally of English, and to a very small extent, of Prussian manufacture.

Four large steel works for making rails have already been established in this country, and a fifth is nearly completed. John A. Griswold & Co., proprietors of the Bessemer Steel Works of Troy, N. Y., made about 2,000 tons of steel rails, half of them for the Erie railroad, prior to the burning of their works in October, 1868. None of these rails have broken, and official certificates testify that they are equal to the best foreign rails. The new works, now nearly completed will enable the proprietors to produce steel rails at the rate of 15,000 to 20,000 tons per year. The Pennsylvania Steel Works, at Harrisburg, are now, and have been for some time producing steel rails at the rate of 12,000 tons annually. These are mostly laid on the Pennsylvania Railroad, and the official reports show them to be equal to the best foreign rails. The yearly capacity of the works is 20,000 tons. The Cleveland Rolling Mill Company are producing steel rails at the rate of 6,000 to 8,000 tons per year. They have only recently started and are not yet in full operation. Their capacity is 15,000 to 20,000 tons per year. Their steel is of Lake Superior iron and is of excellent quality. The Freedom Iron and Steel Works at Lewistown, Pa., are producing rails for the Pennsylvania and other roads at the rate of some 8,000 tons per year. Their annual capacity is 10,000 to 12,000 tons. Their steel is pronounced by the Pennsylvania Railroad Company, after rigid tests, equal to the foreign. The Cambria Iron Company have a Bessemer steel works nearly completed at Johnstown, Pa. Its capacity will be 20,000 tons. The above statements are authoritative and clearly indicate that we shall be able, by next year, to produce annually at least 80,000 tons of good, American-made, steel rails, a fact full of promise for the future of American railways. It may also be stated here that the proprietors of one of the largest iron rail-making establishments in Pennsylvania, after struggling vainly for four years against the rising steel-rail tide, are now negotiating for the services of able and experienced German engineers and metal-workers, with a view to immediately establishing steel works, at which they confidently expect, within a year, to produce steel rails equal to the best for $75 a ton, which is less than the present price of good iron rails! The report quoted above states that some 7,000 tons of domestic steel rails have already been laid, and it is certainly safe to assume that 5,000 tons will be laid this season, making a total in round numbers of at least 12,000 tons (120 miles) of American steel rails in use in the United States at the end of 1869.

The great advantage of steel rails lies in their homogeneity. An iron rail, or a steel-headed rail, is made of a pile of bars heated and welded together, but a solid steel rail is rolled from a single ingot, and consequently is subject to wear only, whereas the others are exposed to "wear and tear," and the "tear," as any one must know who has ever noticed the battered, laminated, and disintegrated condition of iron rails, on a much used track, is a most serious consideration. So great is this advantage that a single steel rail has been known to outwear no less than 23 iron rails placed successively in the same track, and it is perfectly safe to say that any good solid steel rail will outlast a dozen rails of iron. The argument that steel rails are worthless when once worn out never had much force, and is now entirely upset by the discovery of the Martin process, by which old steel can be reworked with perfect ease. And the grand objection that steel is brittle, and, therefore, steel rails must break, is now fully overthrown by actual experience. Of course steel rails may be made so brittle as to be worthless, and it is well ascertained that punching holes in them has a most injurious effect; but this process is now discontinued, and it is certain that rails rolled from good Bessemer steel and drilled, instead of punched, are not only far more durable, but are at least as tough as the best iron rails.

Steel and Steel-Headed Rails.—The following is Mr. Abram S. Hewitt's circular to railway managers, containing the conclusions arrived at during his late investigations in Europe on this subject:

Having made a visit to Europe during the past summer, with Mr. John Fritz, Manager of the Bethlehem Iron Works, at Bethlehem, Penn., for the purpose, mainly, of acquiring information in regard to the use of steel for rails, I do not think that I can render a more acceptable service to the railroad interests of the United States than by making a brief statement of the conclusions at which we arrived.

First.—It appears to be certain that on all roads doing a large business, and especially where heavy engines are run at a high speed, steel must be substituted for iron, on the wearing surface of the track. The steel may be either puddled, or made by the Siemens-Martin, Bessemer, or crucible process; but, whatever kind of steel may be employed, care must be taken that the steel be of good quality, and adapted to the purpose. This demands skill in the manufacture, and care in the inspection. Unless this skill is used, and care exercised, there will soon be the same complaint in regard to the quality of steel as has existed in regard to the quality of iron.

Second.—For roads having a small traffic, iron rails are, as yet, more economical, provided light engines and moderate speed are employed. If proper care is used in the manufacture and inspection, and a price paid sufficient to cover the cost of good materials and workmanship, there is no more difficulty now than there was in former years in procuring iron rails of good quality. The real cause of the inferiority of modern rails appears to be due solely to the unwillingness of railroad managers to pay a price adequate to meet the actual cost of good iron and skillful work.

Third.—The question as to whether all steel rails, or iron rails with steel heads, should be used, is mainly one of first cost. There have been slight objections to steel-topped rails, when cast steel is used for the head arising out of the liability of the steel to separate from the iron, but this objection is now removed both in Europe and in this country, by the experience which has been gained at Dowlais in Wales, and at Trenton in New Jersey; and it is safe to affirm that steel and iron can be certainly united so as not to separate in the weld. The experience with the Booth rail on the New York Central Railroad also goes to show that it is not necessary to weld the steel and the iron at all, leaving it merely a question of prime cost as to whether the heads shall be welded or not. As to all steel rails, whether made from Bessemer, Martin-Siemens, or crucible steel, the only objection appears to be in their liability to break in very cold weather; but the percentage of such accidents is very small—and all things considered, it is difficult to decide whether this objection is of more weight than the possibility of a separation of the steel from the iron in the steel-topped rails.

On the whole, we came to the conclusion that we would take either the *all-steel* or the *steel-topped* rails properly made, giving the preference to the one which could be supplied at the lowest price per ton. In other words, we believe that the question of first cost should alone decide whether to use steel-topped rails or rails made entirely from steel, provided the quality of the materials used and the workmanship is equally good in both cases. The Siemens-Martin process has solved the only difficulty which existed in regard to steel rails when worn out, by working them over as the raw material for new rails. This process is now in operation at most of the leading works in Europe, and can be seen at work at Trenton, N. J., producing steel which welds perfectly to iron, and therefore admirably adapted for steel tops.

The Manufacture of Steel. — The Paris "Presse" says:—"An experiment of a most interesting character, and having the highest interest for the iron industry, has taken place at the Marquise Stock Works, in presence of two eminent persons of the Ecole Centrale. The object of this experiment was to make steel by one operation, a problem which has engaged all metallurgists, and if solved, would cause an industrial revolution. M. Aristide Berard, an engineer whose name is familiar to all who have occupied themselves with this question, proposed to change second class metal in course of refining into steel of at least ordinary quality, by means of a process alternately oxidizing and reductive. His efforts have been crowned with success. The product obtained by his process, in presence of two competent judges, proved to be steel of good quality, suitable for all purpose, and made with the facility necessary to its application to practical industry. The operation was effected in a reverbatory furnace, lasted about an hour and a half, and was accomplished with as much facility as puddling. In this process, instead of acting on 480 pounds of metal to obtain iron of number one quality, from 6,600 to 11,000 pounds of metal is made by only one operation into steel ingots ready for the workshop, and with an unexpected economy. We will be much deceived if this invention has not in it the germ of a complete revolution in metallurgy."

The Siemens Furnace.—In a paper before the Iron and Steel Institute, Mr. Josiah T. Smith, of the Barrow works, after noticing in detail the application and effect of the gases, added that for many months each producer at Barrow had volatilized 3 tons of coal per 24 hours, and that the greatest economy effected was when the consumption had not exceeded 50 cwt. Estimating the weight of one cubic foot of gas at the ordinary temperature of thin air to be .075 lbs., the volume of carbonic oxide, hydrocarbon and hydrogen, from one ton of coal would be about 53,000 ft., and the volume of nitrogen about 122,000 ft., or making together a total of 175,943 ft. The consumption of coal in the producers at Barrow being 500 tons per week, it gave an amount of gas passing through the tubes at the rate of 6½ ft. per second, of 87,000,000 cubic feet; or through the various furnaces adding the quantity of air there admitted of 6,600 tons. The saving of fuel by this process at Barrow was, over a period of two years, no less than 44 per cent ; but the actual money saving, by the use of a particular kind of coal, had been more than one-half. The yield of the gas furnaces, taken over the same period, showed a saving of 31 per cent as compared with the work at the firing furnaces, and the amount of repairs was just two-thirds of the old cost. In these three particulars was undoubtedly to be found the chief economy; but the adoption of the system enabled them to preserve greater cleanliness and order in their works, and an entire absence of smoke met a difficulty which, in the neighborhood of large towns, was every year becoming a greater grievance. There was, he admitted, a slightly increased outlay on the plant; but taking into consideration the increased capabilities as to quantity, it would be found to represent the difference in cost between the two systems.

Ironmaking in the Cleveland District.—For economizing the use of coke in the blast-furnaces their height has been increased from time to time, from 45 ft. to 95 ft. and upwards. Several of the original 45-ft. furnaces are still standing in the neighborhood of Middlesborough, but disused. It has been found at the five furnaces of Messrs. Bolckow and Vaughan that the furnaces of 95 ft. high and 16 ft. bosh are a little more economical as to the use of coke than the other three furnaces of the same height; two of them are 23 ft. and the other 22 ft. in the bosh; the capacity of the latter is about 20,000 cubic ft., and of the former about 10,000 ft. The production of pig-iron will not be in the same ratio, but is greatly augmented in the larger capacity. Another question of economy is the heat of the blast. It appears that with the blast heated to 1300° in high furnaces, 22 cwts. of coke are required in reducing 1 ton of pig-iron. and 1 cwt. of coke is saved for every 100° increase of blast, from 650° to 1150° and upwards. As the blast is heated invariably with the waste gases of the blast-furnace, this saving represents a direct economy in fuel. The blast-furnaces in the Cleveland district are closed at the top with bells, with the exception of the furnaces at Grosmont, the gases from which are withdrawn by means of chimney draught. At the furnaces of Messrs. Bolckow and Vaughan calcining kilns, 45 ft. high, 21 ft. in diameter, are erected of 18 in. fire-bricks, covered with ½-in. plates. The yield of iron from raw ore is about 30 per cent. One ton of coal will calcine about 40 tons of ironstone in these kilns; the calcined stone is let out from the bottom of the kilns direct into barrows. The coke is deposited in hoppers, and is let out at the bottom into barrows by sluices, and afterwards raised to the top of the furnaces. The mode of raising materials from the ground to the top of the furnaces in most cases is by water-balance, the supply water being pumped into a tank by a steam engine. Two works have hydraulic hoisting apparatus, some by pneumatic pressure, and others by direct steam power.—*Mining Journal.*

Krupp's Bessemer Rails.—The manufacture of Bessemer steel rails is now very extensively carried out in the works of Herr Krupp, at Essen. There are four converters used only for rail making. The steel ingots obtained are cylindrical, one ft. six in. diameter, and five ft. high. These ingots are hammered under a steam hammer of eight tons, and reduced to an octagonal section twelve in. wide. They are then rolled through a rolling mill worked by a 100-horse power horizontal and direct-acting engine. This engine, which is not condensing, runs at 50 revolutions per minute, and has a fly-wheel 46 ft. diameter, weighing 60 tons. The ingot is thus converted into a rectangular bar 5¾ in. thick and 7⅝ in. wide; this bar is divided into six or eight pieces, under a steam hammer of four tons. Each of these pieces is used for making rails; they are rolled through a steam rolling mill worked by a 500-horse power steam engine to the speed of sixty revolutions per minute. This system of manufacture enables us to get rid of the globules which have been ere now the most grievous defect of the steel rails, and which are more easily expelled from a large ingot than a small one.—*The Engineer.*

Wrought-Iron Chimney.—A new wrought-iron chimney has been recently erected at the Creusot Ironworks. It is 197 ft. high and 6 ft. 7 in. diameter. At the bottom the diameter is increased to 10 ft. by a curved base, which is fastened by vertical bolts to masonry work. The thickness of the sheet-iron is 3-32 in. at the top, and 7-16 in. at the bottom. There is an inside iron ladder. The weight of this chimney is 40 tons; it has been riveted horizontally, and lifted afterwards with a crane. Another one, 275 ft. high, will be soon erected, but by a different system; it will be riveted vertically, with an inside scaffolding. These chimneys are built for an extension of the Creusot Works, especially intended for steel making. There will be eight Bessemer converters, where the cast-iron will be run direct from the blast-furnace; there will be also many Martin's furnaces, and an extensive workshop for melting steel in crucibles, where it will be possible to melt together 50 tons of steel.

Accident at a Bessemer Works.—A serious accident has occurred at the Atlas works, belonging to Messrs. John Brown & Co. (Limited) at Sheffield. Six men were engaged in casting an immense ingot, when the vessel, which contained about seven tons of molten metal, was overturned, in consequence of the chain which balances it giving way. The whole of the red-hot steel was cast upon the floor. Three workmen were very severely burned. The metal spread all over the floor of the workshop, which is situated in the Bessemer department of the manufactory, and several other workmen, who were some distance from the moulding apparatus, had very narrow escapes.

Production of Rails in France.—A table which has been prepared in illustration of the production of rails in France during the last ten years presents the annexed results: 1859, 101,426 tons; 1860, 121,438 tons; 1861, 164,371 tons; 1862, 216,175 tons; 1863, 226,948 tons; 1864, 215,983 tons; 1865, 184,131 tons; 1866, 159,061 tons; 1867, 154,351 tons; and 1868, 202,204 tons. The average price per ton in 1859, was £10 2s. per ton, while, in 1868, it had fallen to £7 2s. per ton.

British Blast-Furnaces.—The number of furnaces in blast, in 1868, was 560; and the make of pig iron in Great Britain amounted to 4,970,206 tons, an increase of 209, 183 tons over 1867. In England the make was 2,970,905 tons, an increase of 159,959 tons; in Wales and Monmouthshire, 931,-301 tons, an increase of 12,221 tons; in Scotland, 1,068,000 tons, an increase of 37,000 tons.

Magnetization of Iron and Steel.—At a recent meeting of the Academy of Sciences, at Vienna, Herr A. Waltenhofen read a paper on the limits of the magnetization of steel and iron. As a general result he finds the potential temporary magnetization of iron to be about five times greater than that of the best steel.

Catasaqua Manufacturing Co.'s Iron.—Tests at the Scott foundry, Reading, give specimens of three brands of this iron—66,000 lbs., 68,400 lbs. and 74,600 lbs. tensile strength, respectively.

Steel Boilers.—Messrs. D. Adamson & Co. are now making steel boiler shell rings in one plate, measuring 27 ft. in length, and weighing upwards of 16 cwt. each.

ORDNANCE AND NAVAL NOTES.

The "Inconstant."—This fine frigate, of 4,060 tons measurement, 1,000-h.p. (nominal), carrying as her armament ten 12 ton 9 in. and six $6\frac{1}{2}$ ton 7in. muzzle-loading rifled guns, mounted on iron carriages and slides—the pioneer of the new type of unarmored iron-built war frigates introduced into the English navy by the present Chief Constructor —has been put through her official speed trial at her load draught of water over the measured mile in Stokes Bay, near Portsmouth, and by the exceptionally high rate of speed she attained more than confirmed the strongly favorable opinions of her powers created by her previous performance on her preliminary trials, and also exceeded the estimate of her speed given in officially to the Admiralty by her designer. The speed trials of the Inconstant are without doubt the most important by far of all that have yet been made over the measured mile in this country. She is a war frigate designed for special services, requiring exceptional speed under steam, and in all respects intended for competition with the flying unarmored war frigates lately added to the American Navy, and whose powers for offense and flight under steam have been so highly eulogized in the official documents reporting upon their trials and handed in by the officers conducting them to the secretary of the United States Navy. In the American official documents the Wampanoag was said to have steamed at the rate of 16.7 knots per hour for 37 consecutive hours, in a strong beam sea and wind, over a given distance along the coast line. This was stated in the reports to have been done by the Wampanoag, at her proper seagoing trim, and with all weights on board; but now this is flatly contradicted on this side the Atlantic, and the Wampanoag is asserted to have attained her extraordinary rate of speed under conditions different from those given in the official reports. It would be of some value to us to learn the exact truth relating to the trials of the American unarmored frigate, in order that we might obtain some reliable standard by which we could measure the value of our own frigates of a similar character. Sixteen and three-quarter knots per hour continued for 37 hours by the Wampanoag is, on the face of the assertion, an almost incredible performance for any ship carrying 15 in. guns and exceptionally heavy weights in engines and boilers, unless she was greatly assisted by her sails, and until some precise information be given as to how the distance run in the 37 hours was arrived at, the Wampanoag will be only considered really to be what she is asserted to be in this country—a 14 knot ship; and in that case the Inconstant is the faster ship of the two by $2\frac{1}{4}$ knots per hour.

On weighing her anchor from Spithead for her trial the Inconstant drew 20 ft. 8 in. of water forward and 24 ft. 7 in. at the stern. She did not carry her crew, powder and shell, and a quantity of stores, but the weight of all these matters was placed on board for trial in the shape of iron ballast, and, in addition, she carried about 40 tons extra weight in coals, &c., so that her trials were made at a draught of water an inch or so in excess of what it will be when the ship actually proceeds to sea.

Subjoined are the results of the trial. Full boiler power, measured mile runs:

No. 1.—Speed of ship, 16.901 knots; revolutions of engines—per mile 259, per min. 73.5; steam, 30 lbs.; vacuum—forward 25.5, aft 25.5.

No. 2.—Speed of ship, 15.385 knots; revolutions of engines—per mile 287, per min. 74; steam, 30 lbs.; vacuum—forward 25.5, aft 25.5.

No. 3.—Speed of ship, 17.822 knots; revolutions of engines—per mile 252, per min. 75; steam, 30 lbs.; vacuum—forward 25.5, aft 25.5.

No. 4.—Speed of ship, 15 knots; revolutions of engines—per mile 298, per min. 75; steam, 31 lbs.; vacuum—forward 25.5, aft 25.5.

No. 5.—Speed of ship, 18.367 knots; revolutions of engines—per mile 269, per min. 75.5; steam, 30 lbs.; vacuum—forward 25.5, aft 25.5.

No. 6.—Speed of ship, 14.754 knots; revolutions of engines—per mile 304, per min. 75.5; vacuum—forward 25.5, aft 25.5.

Mean speed of the ship under full boiler power, 16.512 knots per hour! Mean revolutions of the engines during the six runs, 74.48 per minute; mean steam pressure, 28.825 lbs.; indicated power by the engines, 7,343 horse.

Full boiler power circles, 12 men at the wheel:

To Port.—Half circle made in 3 min. 25 sec.; full circle made in 6 min. 48 sec.

To Starboard.—Half circle made in 3 min. 11 sec.; full circle made in 6 min. 10 sec.

Half boiler power, measured mile runs:

No. 1.—Speed of ship, 15.789 knots; No. 2.—Speed of ship, 11.613 knots. Mean speed of the ship under half boiler power, 13.701 knots per hour; mean revolutions of the engines, 59.95 per minute. Mean steam pressure, 14.227 lbs.; indicated power by the engines, 3,532.29 horse.

Half boiler power circles, 14 men at the wheel:

To Port.—Half circle, 3 min. 56 sec.; full ditto, 7 min. 50 sec.

To Starboard.—Half circle, 3 min. 42 sec.; full ditto, 7 min. 6 sec.

The Inconstant has a balanced rudder like the Bellerophon. Hercules and Captain, but in her case the fore part of the rudder was reduced in area very considerably the last time she was in dock, and perfect command is now kept over the ship by the men at the wheel, however far the helm may be put over. On her light draught trial the vibration on board was found to be very great, but since the ship has been brought down deeper in the water this has been materially lessened and when the engines were being driven at their highest speed, the vibration exhibited by the hull of the ship was nothing at all extraordinary or beyond what is usually felt under such circumstances. The engines, which were in charge of Messrs. Anderson and Knight, as the representatives of the manufacturers Messrs. John Penn & Son, gave satisfaction in every respect to the Government officials on board.—*Artizan.*

War Expenditure.—The annexed table is extracted from a paper on war taxation, by Mr. William Stokes, which was recently read before the National Reform Union, at Manchester. Mr. Stokes' object was to set forth the permanent consequences of what he terms profligate war expenditure and periodical invasion panics. The conclusion he draws from the figures is that the industry, trade and manufactures of Great Britain are more shackled and burdened by needless taxation than those of any other nation :

	National debt. £	Amount per head. £	s.	d.
1. Ducal Hesse	228,916	0	5	4
2. Sweden	4,114,880	1	0	0
3. Norway	1,854,157	1	1	10
4. Chili, S. America	2,933,405	1	15	0
5. Prussia (1866)	42,123,064	1	15	8
6. Turkey	69,142,270	1	19	1
7. Oldenburgh	621,585	2	1	2
8. Electoral Hesse	1,485,892	2	9	6
9. Brazil	30,762,289	3	1	3
10. Hanover	6,423,955	3	3	6
11. Russia	274,544,770	3	14	1
12. Wurtemberg	7,033,911	3	19	6
13. Saxony	9,912,049	4	4	10
14. Belgium	25,070,021	5	0	7
15. Brunswick	1,707,707	5	16	5
16. Bavaria	29,669,267	6	3	5
17. Baden	9,256,728	6	9	6
18. Austria	268,965,064	7	5	3
19. Denmark	14,862,465	8	18	9
20. Italy	211,503,298	9	8	3
21. Portugal	42,930,472	9	17	4
22. Spain	163,927,471	10	4	6
23. Greece	14,000,000	12	15	3
24. France	566,680,057	14	18	9
25. Hamburgh	4,222,897	16	16	5
26. United States	579,880,391	18	18	9
27. Holland	81,790,799	21	17	10
28. Great Britain	797,031,650	26	10	0

The North German Fleet.—The Imperial Navy of North Germany dates its origin from the year 1848, when the Danish war demonstrated to Prussia the necessity of establishing a fighting fleet and showed the position of a nation lacking this branch of military power. Denmark, a country insignificant in comparison with the German Principalities, was enabled to inflict vital injuries which they were powerless to prevent or to resent. At first the want of union among the German States made itself very strongly felt during the establishment of the fleet, and instead of a combination of all the resources at command they were wasted to create two navies—one in the North Sea, and a Prussian fleet in the Baltic. And all the money which could be gathered for the purpose was absorbed without a German fleet being created. In despite, however, of all these unfavorable circumstances the Prussian navy has so far increased, during the last twenty years, that it has developed from an insignificant fleet of gunboats to a marine, comprising thirty steam and six sailing ships, besides gunboats and vessels for harbor defenses. The navy comprises the fighting and training ships, transports, coast-guard vessels, and those for the defences of ports and harbors. Of the first named, five are armor-clad—the rest of wood, which are still considered capable of good service; the training ships being for the most part disrated sailing vessels, in which officers and seamen receive their professional training.

The following table shows the actual strength of the effective navy of North Germany :

Name of Ship.	No. of guns.	Horse power.	Tonnage.
ARMOR-CLAD FRIGATES.			
Kœnig Wilhelm	23	1150	5938
Friedrich Karl*	16	950	3800
Kron-Prinz	16	800	4404
ARMOR-CLAD TURRET SHIPS.			
Arminius†	4	300	1239
Prince Adalbert‡	3	300	779
WOODEN CORVETTES WITH PROTECTED BATTERIES.			
Elizabeth§	28	400	2026
Hertha	28	400	1746
Vineta	28	400	1746
Arkona	28	386	1621
Gazelle	28	386	1621
CORVETTES WITH BATTERIES EN BARBETTE.			
Medusa	17	200	925
Nymph	17	200	925
Augusta	14	400	1462
Vittoria	14	400	1462
DESPATCH BOATS.			
Eagle	4	300	800
Loreley	2	120	332
ROYAL YACHT.			
Cricket	2	160	493
1ST CLASS GUNBOATS.			
Basilisk	3	80	326
Lightning	3	80	326
Chameleon	3	80	326
Comet	3	80	326
Cyclops	3	80	326
Dolphin	3	80	326
Dragon	3	80	326
Meteor	3	80	326

* Length, 290 ft. 4 in.; beam, 53 ft. 3¾ in.; draught, 23 ft. 9½ in.; armor, 5½ in. thick.

† Length, 200 ft. 1½ in.; beam, 36 ft. 1 in.; draught, 13 ft. 11 in.; armor, 4 9-16 in. thick.

‡ Length, 158 ft. 6½ in.; beam, 32 ft. 9 in.; draught, 14 ft. 10 in.

§ Length, 231 ft. 7 in.; beam, 43 ft. 3 in.

Name of Ship.	No. of guns.	Horse-power.	Tonnage.
2d class gunboats.			
Fox	2	60	233
Shark	2	60	233
Vulture	2	60	233
Hyena	2	60	233
Chasseur	2	60	233
Aspic	2	60	233
Arrow	2	60	233
Salamander	2	60	233
Nightingale	2	60	233
Scorpion	2	60	233
Sparrowhawk	2	60	233
Tiger	2	60	233
Wasp	2	60	233
Wolf	2	60	233
Sailing Ships.			
frigates.			
Gefion	48	....	7406
Thetis	38	....	1557
Niobe	26	....	1052
briggs.			
Mosquito	16	....	549
Rover	16	....	552
Hela	6	....	253

Besides these there are five vessels for harbor service, thirty-two yawls armed with two guns, and four with one gun each.

Two corvettes are in course of construction—the Hansa, with an armor-plated battery of eight guns, and of 450 horse power; and the Ariadne, a wooden ship, with a battery of six guns and with 360 horse power. Altogether the Prussian navy possesses 90 armed vessels of all denominations, mounting, collectively, 1,549 guns; but few of these, however, were built at any of the Imperial dockyards.—*Engineering.*

Shoeburyness Experiments on Shells and Fuses.—A series of experiments were recently conducted at Shoeburyness, with the object of ascertaining the relative efficiency of the Palliser shells, having their heads chilled and bodies cast in sand, the merits of shells made of Firth's steel, and containing large bursting charges, and to determine the reliability of a new form of fuse designed by Lieutenant E. Boxter, R. N. All the rounds were fired from the 9 in. Woolwich rifled gun, with full battering charges of 43 lbs., at a range of 200 yards, against an 8 in. plated target, with 18 in. teak backing and $\frac{3}{4}$ in. skin. Five rounds were fired with the compound Palliser projectile (having the chilled head and soft iron body), and two rounds with shells of Firth's steel, the first, third, fifth, sixth and seventh rounds being with the former, and the second and fourth with the latter class of projectiles.

In the first round the Palliser shell effected a penetration of 22 in. from the back of the head, which remained in the hole, the body being blown out in front of the target.

In the second round with a hardened Firth steel shell, penetrated to a depth of 26 in., the shell bursting in the backing, and the body being blown out of the shield.

The third round with a Palliser shell, penetrated to a depth of $25\frac{1}{2}$ in., tearing away the backing, and tearing some of the backing girders.

The fourth round, a Firth's steel shell, penetrated to $8\frac{1}{4}$ in., making a hole 10 in. by 11 in. The effect of this round manifested itself in stripping off flakes of the plates in the vicinity of the point of impact.

The Boxer fuse, which has been adapted to the Palliser shell, is intended to be used in those projectiles which are fired against wooden or thinly-plated ships, which are now penetrated by shell with the same effect as by solid shot. The fuses are made of gun-metal, and are screwed into the rear of the shell through a gun-metal bushing. In the front of the fuse plug, in a cylindrical recess, is placed a small cylinder of lead behind a gun-metal hammer, which is suspended by a wire. In front is placed the fulminate upon a disc in contact with a pellet of compressed powder. When the gun is discharged the leaden cylinder is compressed, and the hammer is liberated by the shearing of the wire which suspended it, and so soon as the shock of impact occurs, the hammer springs forward, and, striking the fulminate, explodes the shell by means of the powder pellet. The act of explosion, however, occupies a space of time sufficient to allow of the passage of the projectile through the wooden sides or the thinly armored walls of a ship.

Three experimental rounds were fired with shells provided with these fuses with the object of ascertaining whether the efficiency of the Palliser projectile would be impaired when fired against thick plates. In all these rounds a complete peuetration was effected, as well as a marked superiority in the amount of damage.

The experiments of the day were completed with some rounds fired from a 9-pounder Indian brass field gun, to ascertain the value of a new fuse, being a combination of the service Boxer wood time fuse and a modification of Captain Freeburn's concussion fuse, adapted for light field pieces as well as for heavy guns—*Engineering.*

Pontoons for Transport Ships.—About two years since Admiral Mends proposed the construction of pontoons for the service of the new very large transport ships Serapis, Euphrates and Crocodile. The first pontoons which were constructed for the Serapis were of cylindrical form, and were built of steel by Maudslay. Four were made to constitute the raft, the weight of each being about $2\frac{1}{4}$ tons. On the trial of them before the naval and military authorities at Woolwich, it was suggested that pontoons constructed of Mr. Clarkson's cork material would possess qualities of lightness, strength, and buoyancy peculiarly suitable for the operations such pontoons would be called upon to perform, and that they would also be more easily repairable if damaged by musketry fire. Four pontoons of the following dimensions were ordered for experimental trial, and these were launched into the Thames on Monday last. Their dimensions are: Length, 36 ft.; diameter, 4 ft. 6 in. A light framework is made of wood as the skeleton of the structure. The form is then completed by planking of $\frac{1}{4}$ in. thick pine wood, both sides of which are covered by stout canvass adhering to the surfaces by a waterproof solution. Over this sheet cork is applied by the same adhesive substance; the whole pontoon is coated with the solution, and a strong jacket of canvass is superadded as the external covering. The advantage of this material is that it possesses elasticity and such capacity of cushioning blows that the vessel receives no injury from such concussions as would be liable to fracture or indent metal structures; and with the passage of shot there is an absence of splinters, and a natural tendency on the part of the cork material to close up the orifice made by the missile. The four pontoons were manufactured in London, and floated down the river to the factory of Messrs. Maudslay, Sons and Field, where they were fitted together by spars and lashings, and a stage or platform for landing or embarking guns, troops, horses, &c., erected upon them. The pontoon was then towed down by the Bustler, Admiralty steam tug, to Woolwich dockyard.

THE TURRET SHIP MONARCH.—The following notes of the dimensions and performance of the two-turret armored ship Monarch will be found of interest:

Length between perpendiculars...	330 ft.
Extreme breadth................	57 ft. 6 in.
Depth of hold..................	18 ft. 8 in.
Tonnage........................	5,102 tons.
Draught load on trial—forward...	21 ft. 10 in.
" " —aft.......	25 ft. 8 in.
Displacement "	8,070 tons.
Engines, nominal HP...........	1,100.
Cylinders, diameter.............	120 in.
" stroke............ ..	4 ft. 6 in.
Indicated on measured mile......	7,842 HP.
Revolutions, mean "	63.61 "
Indicated on six hours' trial......	7,470 "
Revolutions, mean, six hours' trial,	62.67 "
Steam in boiler, measured mile....	31.33 lbs.
" " six hours' trial....	30.58 "
Midship section.................	1,208 sq. ft.
Mean speed, measured mile......	14.937 knots.
$\frac{V^3 MS}{I H P}$ "	513.4
$\frac{V^3 D^{\frac{2}{3}}}{I H P}$ "	171
Mean speed, six hours' trial......	14.715 knots.
Co-efficients as above............	515.3 and 171.6.

The Monarch has nine boilers, containing forty furnaces, the area of grate being 770 sq. ft., while the total heating surface is 20,900 sq. ft. There are 3,600 sq. ft. of superheating surface, and the surface condensers present 16,500 sq. ft. of surface. The Griffiths' screw is 23 ft. 4 in. in diameter, and 26 ft. pitch. The armament of the Monarch consists of two 25-ton rifled guns in each turret, besides three smaller guns on deck. Each turret is 26 ft. 6 in. in external diameter, and 22 ft. inside, the solid rolled plates around the ports being 10 in. thick, while at other parts of the turrets the thickness is 8 in.—*Engineering.*

THE STEVENS BATTERY.—The celebrated "Stevens Battery" is still at the yard in Hoboken, where her keel was laid long ago. The ban of secrecy has not yet been removed from the work on the vessel, which, however, is still steadily progressing. Our reporter visited the yard yesterday, and was enabled to gain a few facts in regard to the construction of this modern marine monster. The vessel as she stands is 250 ft. in length, 30 ft. in breadth and draws 27 ft. of water. Her hull is composed of teak wood two feet in width, with a covering of four inches of iron, which is screwed on with copper bolts. Her decks are composed entirely of iron, and the battery which she is to carry, is to consist of four guns of enormous caliber, throwing a solid ball of 700 pound weight. She will have two screw propellers, and it will be impossible for her to turn within a space equal in length to that of the vessel. General McClellan is at present superintendent of the work, and he has 180 men employed. The ram is to be completed during the year 1871, when it will be presented to the State of New Jersey, as a protection to New York Harbor. Thus, says a New York Daily, very correctly, only the length of the vessel is 420 ft. instead of 250, and 45 ft. beam instead of 30; and she is built of iron instead of teak.—ED. V. N. M.

IMPROVEMENTS IN MUSKETS.—The equipment of a musketeer, as late as 1689, was very cumbrous. He was provided with a heavy wooden fork, which he had to stick into the ground with the prongs uppermost, to serve as a support for his matchlock, which he had to load with his powder-horn and measure, keeping the ball meanwhile between his lips. The wadding he had to get from his hat. Nevertheless, the wheel-lock, provided with pyrites instead of flint, had long been invented, but seems never to have come into general use in armies, except for cavalry pistols. The French lock which preceded the percussion system was invented as early as 1640, though it, of course, received successive improvements. But even before that time Gustavus Adolphus had introduced a great improvement in musketry, by reducing the weight of the piece to 10 lbs. instead of 15 lbs. This enabled the soldier to do away with the fork, and therefore increased the rapidity of the fire. The bullet weighed an ounce. Another improvement of his was the paper cartridge, which, however, at first only contained the powder, the bullets being kept in a bag.

PALLISER MORTAR.—A 13 in. sea service mortar of five tons weight has been ordered to be converted upon Major Palliser's plan into a 9 in. rifled mortar of about $6\frac{1}{4}$ tons weight, to fire the 9 in. service rifled shell, which contains a bursting charge of 18 lbs. of powder. The bore of the mortar will be elongated to about 4 ft. 6 in.; and a range of about 7,000 yards is expected to be obtained from a charge of 20 lbs. of powder. Some further experiments are being carried on with two 10 in. shell guns, which are being converted respectively into an 8 in. and a 7 in. rifled gun, in order to determine the most suitable caliber for the conversion of cast iron 10 in. shell guns. The whole of the 212 8-in. guns converted into 6.3 in. rifled guns by Sir Wm. Armstrong & Co. have been passed into the service, and 200 more are in course of conversion in the royal gun factories. It is probable that a considerable number of guns will be converted next year for land defenses, the whole of the above 437 guns being for the navy.

HARVEY'S SEA TORPEDOES.—A considerable number of these formidable machines have been supplied by the maker, Mr. William Nunn, of St. George street, London Docks, to the Russian Government.

Foreign 20-in. Gun.—Some interesting experiments have taken place at Perm with a new 20 in. gun, cast in the foundry of that town. The trials made with this gun, under the direction of Major General Prestitch, commandant of the Cronstadt artillery, are described in the officiale rports as having been very successful, and more satisfactory in their results than had been the case with American guns of the same caliber. The gun was fired 314 times; the projectile weighs 10 cwt., and the charge of powder required for each shot was 130 lbs. The weight of the gun is about 50 tons, the recoil 7 ft., the initial velocity of the projectile 1120 ft. per second, and the percussion force at a distance of 50 ft., about 10,000 tons. The official papers say this is ' the most powerful gun in Europe.

Explosive Compounds.—Mr. F. A. Abel, has communicated a long paper to the Erench Academy on the properties of explosive compounds, which contains the results of experiments with gun-cotton, gun-powder, nitro-glycerine, &c. He accounts for the difference remarked in the nature of the explosion produced by various substances when they act upon matter of a different kind by supposing that the explosion produces a certain kind of vibration that may or may not be synchronic with that produced in the body operated upon by the explosion.

Armstrongs for Greece.—The screw steamer Hotspur has lately sailed from Lynn for the Tyne, and taken on board a cargo of Armstrong guns. These Armstrongs are intended for the Greek government.

RAILWAY NOTES.

Great Western New Narrow Gauge Engines.—The following are the principal dimensions of the new locomotive engines of the Great Western Company. The boiler is 10 ft. 6 in. in length, and 4 ft. diameter inside. It is of 7-16 in. plates, the tube plates are $\frac{5}{8}$ in., the angle irons $3\frac{1}{2}$ in., the rivets $\frac{3}{4}$ in. diameter, are $2\frac{1}{8}$ in. between centers; there are six stays of an inch diameter, and two gusset stays. The outside fire-box is 5 ft. 1 in. long, by 4 ft. $1\frac{1}{4}$ in. broad, and as regards height is flush with the barrel; it is 2 ft. 8 in. below the boiler, and is of 7-16 in. plates, bound by $\frac{3}{4}$ in. rivets at $1\frac{7}{8}$ in. centers; it has 540 stays $\frac{7}{8}$ in. diameter; the distance of the copper stays apart average 4 in. The inside fire-box is of copper, and is 4 ft. 6 in. long by 3 ft. 6 in. wide, and is 5 ft. 6 in. from the bottom to the top of the box; it has nineteen fire-bars 1 in. distance apart; the area of the fire-grate is 15.75 ft. The superficial area of the box is 87 ft.; the steam-pipe is 5 in. diameter. The tubes, iron, are 10 ft. $9\frac{3}{4}$ in. long; in outside diameter 2 in. and $1\frac{5}{8}$ in.; they are $2\frac{5}{8}$ in. between centers, and in number are 161 of 2 in. and fourteen of $1\frac{5}{8}$ in., or 175 in all, giving a superficial area of 999 square feet, and a total heating surface of 1,086 square feet. The smoke box is 2 ft. $5\frac{3}{4}$ in. in length, by 4 ft. $8\frac{1}{2}$ in. broad, and of $\frac{1}{4}$ in. plate. The chimney is 1 ft. 4 in. diameter, of $\frac{1}{8}$ in. plate, and has an extreme height of 14 ft. 6 in. above the rail. The blast pipe, of cast iron, is $4\frac{3}{4}$ in. diameter at the top, and is 3 ft. 6 in. high. The pumps, brass have a 2 ft. stroke with a plunger $1\frac{3}{4}$ in. diameter. The diameter of the waterway is $2\frac{1}{4}$ in.; distance of centers, 3 ft. 7 in.; rise and fall of pump clack seat 3-16 in. The safety valves, brass conical, are 4 in. diameter, with 3 ft. centers of levers. The cylinder is 16 in. diameter; stroke, 2 ft.; distance of centers, 2 ft. 3 in.; distance below boiler, 1 ft. $5\frac{1}{2}$ in.; distance of centers of valve spindles, $4\frac{1}{2}$ in. The back and front flanges have ten bolts, $\frac{7}{8}$ in. diameter, in each. The cylinder is $\frac{7}{8}$ in. thick; the piston rod $2\frac{1}{2}$ in. diameter. The distance between inside of ports is 2 ft. $1\frac{1}{2}$ in. The ports are 1 ft. 2 in. in breadth; length of steam, $1\frac{3}{8}$ in.; length of exhaust, $3\frac{1}{2}$ in.; thickness of bridge, $\frac{3}{4}$ in. The slide valves travel 4 in.; the lead is 3-16 in. to 5-16 in.; lap on steam side, 1 1-16 in.; and the eduction overlap, $\frac{1}{8}$ in. The four eccentrics of cast iron, with patent white metal rings, have 3 1-16 in. throw; diameter, 1 ft. $2\frac{7}{8}$ in.; breadth, $3\frac{1}{4}$ in. The regulator, cast iron, with brass slide, has two steamways, $6\frac{1}{2}$ in. by 1 in. The motion bars are 4 ft. $2\frac{3}{4}$ in. long, 3 in. broad, and $2\frac{7}{8}$ in. apart. The driving-wheels are 5 ft. diameter; the outside tire is $5\frac{5}{8}$ in. broad by $2\frac{5}{8}$ in. thick; the wheels are 4 ft. $5\frac{1}{2}$ in. apart; and the cone of the wheel is 1 in 15. The leading wheels are 3 ft. 6 in. in diameter; distance of wheels same as the driving-wheels; cone of wheel, 1 in 10. The trailing wheels are 5 ft. diameter, same distance apart; cone 1 in 10. The distances of the centers of the wheels are—driving-wheels from leading wheels, 7 ft. 3 in.; driving-wheels from trailing wheels, 8 ft. The laminated steel springs for the driving axle are 3 ft. $5\frac{1}{2}$ in. long by 4 in. broad, and consist of fifteen plates, giving a depth of $5\frac{3}{4}$ in. at the center. The springs for the front axle have seventeen plates, and are $6\frac{1}{2}$ in. thick in the center. The extreme length of the frame is 25 ft. 2 in., and the breadth 4 ft. $4\frac{3}{8}$ in. The buffers are 3 ft. 3 in. in height from the rail, and 5 ft. 10 in. between centers. The suction pipes, of copper, are in height 1 ft. 3 in. from the rail; distance of centers 3 ft. 9 in.; diameter of waterway, $1\frac{3}{4}$ in. A tender to these engines needs no description, seeing that they have none. They (the engines) are supplied each with two tanks fixed on platforms over the frames; the capacity of the tanks is 395 gallons each. Coal is carried in a bunk at the back of the foot plate. The tank capacity of an engine, it will be seen, is 790 gallons, but in practice they are never charged with this quantity. The tanks are usually filled to a height of about 13 in. from the top, this restricted height being found necessary for the efficient working of the condensing apparatus. With water to this level, and with coke and sand-boxes full, ready for a trip, the loaded engine is 33 tons 4 cwt. in weight, borne thus:—Leading wheels, 9 tons; driving wheels, 12 tons 2 cwt., and trailing wheels, 12 tons 2 cwt. The weight is reduced to about $31\frac{1}{2}$ tons at the end of a moderate journey. These engines, it may be repeated, have more than fulfilled all the expectations that were entertained concerning them when they were designed and constructed. We have already had occasion to speak favorable of them in our impression for May the 14th. The weight of the various engines now working the Metropolitan Railway, is about as follows:—Metropolitan Company's engines, 42 tons nominal; Midland engines, 45 tons nominal; Great Northern engines, 33 tons nominal; Great Western narrow gauge, 33 tons 4 cwt. actual.—*The Engineer.*

UNDERGROUND RAILWAY LOCOMOTIVES. — Mr. Buckhout, in his report on the New York City Central Underground Railway, describes a general design, and comments as follows:—Gauge, 4 ft. $8\frac{1}{2}$ in. Fuel, anthracite coal or coke. Cylinder, 14 by 22 in., four 56-in. driving wheels, steel tyres, all flanged. Two single axle radiating trucks, one at each end, wheels 30 in. in diameter. Furnace of steel; 126 two-in. flues, 10 ft. 5 in. long. Tank on each side of engine to contain 1,500 gallons. The engine also to be supplied with a blower or steam jet. The engine to be so arranged as to throw the exhaust steam into the tanks so as to condense it, or throw it up the chimney for the purpose of blast for raising steam, and so that the engineer can make the change instantly as required. This engine will take 80 tons in addition to its own weight (68,000 lbs. in running order), with 1,500 gallons of water in the tank, and 600 lbs. of coal, up grades of 1 in 39, or 38 ft. per mile, with a pressure as low as 80 lbs. per in. (if the steam should get so low), cutting off at 60 per cent admission, it being intended to carry a maximum of 130 lbs. per inch. About 1,400 gallons of water will be required for the condensation of the steam for the distance of two miles. consequently it would require changing every four miles, if the steam were condensed for half that distance. The tanks to have a discharge valve by which the water can be let out quickly, when it requires changing. The fixed wheel base to be 6 ft 9 in., and the whole base, including the radiating trucks at each end, to be about 21 ft. 9 in. With this arrangement the truck wheels will not require to radiate over $3\frac{1}{4}$ in. from a straight line, on curves of 200 ft. radius, which is much within the limits of its capability. With equalizing levers, as applied to this description of engine by Mr. Hudson, two-thirds or more of the weight can be carried on the drivers, and the arrangement is such as to accommodate itself to all the vertical and lateral undulations of the track, without varying the distribution of the weight on the wheels; it is also arranged so as to be equivalent in action to a four wheel center bearing truck at one end, and to a four wheel side bearing truck at the other end. In addition to these properties the engine can be run either end foremost with *great facility and equal safety*: a feature not embraced in any four driving wheel single truck engine. It has therefore special advantages in saving the time usually occupied in turning an engine around so as to run truck foremost. It has another advantage. The trucks do not deviate from the center line of engine nearly as much as a faur driving and four wheel swing truck engine does on the same curve, being some 50 per cent in favor of the double truck.

COAL AND SMOKE CONSUMPTION, ON THE PENNSYLVANIA RAILWAY.—In 1859, arrangements were made for a thorough and favorable trial of the Gill patent for smoke and gas consumption, and in the Report for that year (13th A. R.) the Master Mechanic expressed himself as satisfied that "the true secret of consuming smoke has been discovered and rendered practicable." This plan included a "combustion chamber," which it was hoped could be dispensed with—a fire-brick deflector being introduced, involving the same principle. Supt. Scott was also sanguine that a saving of 50 per cent in the cost of fuel could be effected. Although the results are favorably spoken of in the late Report (14th A. R.) it does not appear that the end was attained, although the deflector which was largely introduced (costing $50.00) was regarded as economical, on account of enabling the Company to go back to the plain fire-box which, aside from possessing conditions favorable to combustion, was accessible for inspection and repairs. In the same year (1863), experiments were made with anthracite, an engine being built expressly therefor, with the latest improvements, but it was found that this fuel would not make steam freely enough on long, fast runs with heavy trains. Experiments are now making with an apparatus for bituminous coal, invented by J. T. Rich, of Philadelphia, who puts into the fire box a "dead plate," extending from side to side, sloping from a short distance beneath the door, and then turning down perpendicularly to the great-bars. Above is a fire-brick arch extending from the back well forward, around which the ascending flame must pass toward the front. Outside the door is a hopper, constantly supplied with coal, which it passes in, as that already in the fire-box works down to the dead plate. A fire being started on the great cokes, the coal on the dead-plate; and the heat is utilized by passing around the arch and through the flues. As the coke thus made itself burns away—its heat and gases, without smoke, passing through the flues—new coal constantly works down and undergoes the same process. The experiments thus far show there is no doubt that the process will result in almost entire freedom from smoke; but the practical question whether steam can be made fast enough, is not yet decided. Experiments are also making with coke already prepared; and it is deemed certain, should Mr. Rich's device not succeed, that coke, which can be obtained at morderate cost will be successfully used.—*Chicago Railway Review.*

UNIFORMITY OF LOCOMOTIVES.—The "American Railway Times" makes the following statement which was doubtless intended to be severe:

"Two years ago the Pa. R. managers determined to reduce their rolling stock down to some such simple system as we have indicated; and they have succeeded in reducing the varieties of engines down to 40, in a total equipment of 456 engines. This may be called a *reductio ad absurdum.*

Truly to your genuine nothing-if-not-critical Boston art, "Seneca cannot be too heavy, nor Plautus too light." The "Times" borrowed, and isolated, an expression in the "Review's" article, and chose to interpret it without reference to the full accompanying explanations. The 456 locomotives on the road are all referable to these three classes:

1. *Standard Passengers,* having 17x24 in. cylinders, and $5\frac{1}{2}$ ft. drivers.

2. *Standard Freight,* 40-wheel, having 18x22 in. cylinders, and $4\frac{1}{2}$ ft. drivers; and,

3. *Standard Shifting,* 6-wheel, having 15x18 in. cylinders, and 44 in. drivers.

Of the first class, there are two modifications—the Mountain Helper, having 18x24 in. cylinder, 5 ft. drivers, and large boiler; and a local and fast freight engine differing only in the diameter of the driver, 5 ft.

Of class 2 there is but one modification—a Mountain engine having 4 ft. drivers, and larger boiler. These are the only *classes* recognized; and of all these, the important working parts (castings) are interchangeable—such as driving-boxes, eccentric stops, etc. Of *patterns* there are still well nigh as many as of manufactures; but these embrace only those which have been many years in use, and to have changed which to uniform standard or *pattern* would have necessitated their cutting-up long before this time of service had expired. The P. R. like most roads in the beginning, purchased engines of many different manufacturers; and as these wear out, their patterns disappear, so that within a few years there will be not only one invariable standard of construction, but of style.—*Cor. Chicago Railway Review.*

Improved Locomtive Alarm Bell.—There has been a recent trial on the Detroit and Milwaukie Railway, of an invention or device for ringing the locomotive bell continuously. The device consists of placing an ordinary bell, weighing about 100 lbs., on the front of the locomotive just over the cow-catcher. A rod attached to the eccentric shaft causes a clapper to strike the bell each turn of the driving-wheel. The bell is suspended loosely, and revolves from the force of the stroke it receives, so that all parts of its surface are equally exposed to wear.

The advantages of this arrangement are a continuous sound, slow or rapid in proportion to the speed of the engine, each revolution of the wheel producing a stroke of the bell. In case of accident the railway company can always prove that their bell was ringing according to law, that being the point most difficult to convince a jury, and the one which railways have the greatest difficulty in proving. Owing to the position in which this bell is placed—in front of the engine and about three feet from the ground—the sound can be distinctly heard about three miles in day time, and by night four miles or more, the ground and the continuous rail, both excellent conductors of sound, assisting in carrying the vibrations. The bell may also be rung, if necessary, by a cord from the foot board when the engine is at rest. Quite a number of these bells have been placed on the engines of the Detroit and Milwaukie Railway, and several other companies are giving them a trial. The inventor is Mr. Ben. Briscoe, the master mechanic of the Detroit and Milwaukie road, who has charge of the locomotive works of the company at Detroit, Michigan. He is one of the numerous graduates from the Baldwin Locomotive Works at Philadelphia.—*American Railway Times.*

Iron Cars.—The "Ironmonger" suggests the desirability of constructing trains wholly of iron. They might be so constructed of this material as certainly to offer greater power of resistance in case of collision, and this without materially augmenting their weight, whilst the danger from fire would be almost nil. With strong frames, properly braced, the sides might be covered with comparatively thin sheets of iron. Railway companies cannot certainly be expected, in view of the large intermediate outlay that would be involved in an entire change of rolling stock, to carry out at once the suggestion, but the transformation might be effected gradually, and all carriages hereafter constructed might be of iron. These iron cars would doubtless be more lasting, and, in the end, more economical. Our large iron manufacturers would do well to give this subject their attention.

The Shops of the Pacific Railway at Sacramento.—There are now 160 locomotives at the western end of the road—belonging to the Central Pacific Company—of which 29 can be accommodated at one time in the Sacramento round-house. Its front measures 611 ft.; its rear, 411 ft.; depth, 64 ft.; and height, 24 ft. Water for the engines is supplied from a side tower, called the oil-house, in the top of which is a tank containing 65,000 gallons of water, and below the same two stories for offices, and a cellar which holds seven great sheet-iron 1,000-gallon reservoir for oil, thus secured against fire.

The wood-working and car manufactory is another colossal building, 90x238 ft., of two colossal stories, with straining-beam truss roof, whereby the lower story is kept entirely free and unobstructed. There is also an L 45x90 ft. All the cars, including doors, windows, and upholstery, are made from California material, at a cost quite as low as that of the same articles imported. Numerous band-saws and other of the most complete modern wood-working machines may be seen at work.

The machine-shop is 100x205 ft., beautifully roofed, and filled with superb iron-working machinery adapted to railroad uses. This shop is intended to do all the iron-work of the road, but local repairing, for which shops have been built along the line—as at Rocklin, the "foot of the hill," where there is also a first-class granite round-house, and where two or three additional engines are in readiness to join the single one that does duty for fifty or sixty cars between Sacramento and that place. In the machine shop there are eleven pits, adapted for locomotive repairs, and a traveling bridge, by which locomotives can be picked up and lifted about like toys. The finest engine on the coast furnishes the power—a Corliss engine of 160 horse-power, built in Sacramento.

A blacksmith-shop 60 x 150 ft., to contain 30 forges and three steam-hammers, completes the list of buildings now erected.

Railways in New York.—The report of the State Engineer and Surveyor of Railroads for the last half year, gives the following statistics, which may be interesting to your readers:—

There are fifty-six different railways in operation in the State, the aggregate length of which is 3,053.95 miles, and which have been constructed and equipped at a cost of $208,185,782. Including roads contemplated, the whole number is eighty-one, with a length of 4, 567.99 miles. The oldest line is the Mohawk and Hudson, opened for travel a distance of seventeen miles, in 1831. The number of locomotives in use is 1,111; passenger cars, 1,163; baggage and mail cars, 362; freight cars, 17,934. During 1868, the number of passengers of all classes carried over the State was 18,434,300, and the amount of freight 11,961,692 tons. The cost of operating the roads was $15,250,716; the total payments, $48,274,476; and the total earnings, $49,-377,790. The average rate of speed of ordinary passenger trains, including stoppages, was 18.55 miles per hour, while the average speed of express trains was 29.74 miles. The number of persons killed during the year was 302, and the number injured 358. Of these 104 were killed on the New York and Erie road, out of 2,194,348 passengers carried; on the Hudson River road 27 to 2,626,303; on the New Haven road 6 to 2,192,940; on the Harlem road 20 to 1,667,578; on the Long Island road 4 to 823,000; on the Staten Island road 1 to 349,853. The total amount recovered as damages for injuries to passengers, which the various companies were obliged to pay during the year, was $528,310. The Erie road paid $198,135; the Hudson River Company, $20,745; the New Haven road, $10.937; the Harlem road, $7,865; the New York Central, $72,944; the Buffalo and Erie road, $196,-405.

Steel Fire Boxes for Locomotives.—At the late Master Mechanics' Convention, held at Pittsburgh, a committee was appointed to investigate and report on the question :

Are steel plates preferable to the best iron plates? and if so, does the difference in strength, safety and durability, justify the difference in cost? Also, how, in practical experience, does steel for furnaces compare with copper?

The committee reported much interesting testimony bearing on the subject, among others, the statement of an officer of the Northwestern R. R., who said :

Fifty-one locomotive fire-boxes, made of copper sheets half an inch thick, after thirty months' use, show marked indications of wear, and will probably have to be renewed in a short time. In some cases, after less than three years' service, the original half-inch sheets were reduced to less than one-eighth of an inch.

With reference to the application of steel for the purpose indicated, it was further stated by the same party, that :

On the Northwestern road, a locomotive has been run for eight years with a steel fire-box, which has thus far shown no signs of wear, although the coal and water used had proved extremely detrimental to the iron and copper fire-boxes previously used on the same division of the road.

On the Pennsylvania road, two locomotives fitted with steel furnaces in 1861, still remain intact, and two locomotives on the Baltimore and Ohio, furnished in like manner about the same time, show similar results. The committee unanimously and emphatically concluded "in favor of *homogeneous steel plates* for locomotive fire-boxes, at least of all those that burn bituminous coal; and that for boiler-plates for general construction, this material combines in a greater degree than any other, the requisites of durability, safety and economy."—*Chicago Railway Review.*

The Louisville Bridge.—The great railway bridge on the Ohio river, at Louisville, Kentucky, will be ready for the passage of trains by the end of the present month. It is one of the finest and most important structures of the kind in the country. Its total cost when complete will be about one and one-half million of dollars. The length of the bridge is 5,200 ft., or nearly a mile. It is supported by twenty-five massive piers. The longest span is over the middle chute, and is 370 ft. At this point the bridge is $90\frac{1}{2}$ ft. above low water mark. There is a drawbridge over the canal of $114\frac{1}{2}$ ft. clear span. The grade from the Kentucky side is 82 ft. to the mile, the grade on the Indiana side being nearly 79 ft. A long and heavy embankment is necessary on the west side of the river, and that is nearly done. This bridge in addition to its railroad uses, is built for street cars and wagons, the supposition being that at certain times of the day—only one-eighth of the twenty-four hours—the railroad trains will occupy the bridge, leaving it free the rest of the time for ordinary travel. The estimates of this grand structure tell the story of what it is. The masonry cost $476,962, the iron superstructure $776,090, the whole amounting to $1,600,000.—*Polytechnic.*

Long Railway Running.—In a recent article we referred to several instances of continuous railway "runs" of from 76 to $97\frac{1}{2}$ miles. We should have instanced the mail trains on the South-Eastern line, which, on the old line made 88 miles without stopping. *Via* Sevenoaks, the distance, we believe, is 75 miles. The engines have 16 in. (some of them 17 in.) cylinders, 22 in. stroke, and a single pair of 7 ft. driving wheels. The tenders contain 2,500 gallons of water. The usual train is from fourteen to eighteen carriages, and the average speed is from 40 to 45 miles an hour.—*Engineering.*

A Remarkable Railroad.—The most remarkable railroad in Germany and Europe is the new Black Forest road, which will be completed within four years. Between Hornberg and St. George, situated 2,870 feet above the level of the sea, and but four miles distant from Hornberg, the railroad ascends nearly 2,000 ft., and passes through 27,000 ft. of tunnels. Eleven thousand feet of the latter have been completed during the last two years. The truly cyclopean work on the road is progressing rapidly, and attracting thousands of visitors, who flock there from all parts of Southern Germany and Switzerland.—*Polytechnic.*

NEW BOOKS.

Useful Information for Railway Men. By W. G. Hamilton, Engineer. D. Van Nostrand, 23 Murray street, New York.

We can fully indorse the following notice of this excellent work from "Engineering:"

This pocketbook, which in its original form and first edition was intended to serve no other purpose than a useful advertisement, has in its second issue developed into a *vade mecum*, which will be found more comprehensive and more serviceable than any work of the same kind in existence. The author, Mr. W. G. Hamilton, who is the manager of the Ramapo Wheel and Foundry Company, an establishment but recently established, yet now doing almost the largest business in chilled cast-iron wheels in the United States, contemplated originally the compilation of such a pocketbook from existing works of the same nature, and supplemented by his own notes and those of some other American engineers, as would be compressed into a small volume, that would carry its own recommendation as well as that of the business for which it served as an advertisement. This edition, which was a very large one, was gratuitously circulated throughout the United States, and led to so large a demand that the author determined upon producing a second edition, in which the Ramapo Foundry should make no obtrusive appearance. This is the issue under notice. It consists of 569 pages of very closely printed matter, in which are contained the bulk of Molesworth's, Hurst's and Nystrom's pocketbooks, copious compilations from the principal scientific writers, and, above all, a large compendium of United

States' railway practice. Of course a great deal of its contents have a special value for the American engineer, but these notes recommend themselves most strongly to ourselves, as representing the latest and best practice in the States. The index contains nearly a thousand items, many of which are illustrated sufficiently well to explain fully the subject to which they refer. The extent, cost and general particulars of American railways are given, the standard specification of rails upon the principal railways, the dimensions and description of rolling stock, the most recent improvements in locomotive practice, and epitomes of the financial management of railways. It would, of course, be impossible to convey an idea of the almost endless subjects upon which this little book touches, in each case profitably: it must suffice to recommend it, and to trust that it may be placed within the reach of English engineers.

The Polytechnic.—A Semi-monthly Paper devoted to the interests of Polytechnic and Scientific Schools, and a Record and Review of Civil, Mechanical and Mining Engineering, Natural Science and General College News, Troy, New York. Montague L. Marks, Editor and Proprietor.

We can best state the character of this excellent publication by quoting from its prospectus:

"In adopting the name Polytechnic, our design has been two-fold, viz: First, to identify closely the title of our publication with that branch of knowledge, to the advancement of which it is especially devoted; and Secondly, by the general significance of the name as applicable to all Polytechnic and Scientific Schools, to demonstrate the design of the publisher to make the Polytechnic their common mouthpiece. By arrangements that we have made with some of the most able contributors to scientific periodicals in this country, and with other gentlemen of known ability, in each issue of the Polytechnic will be found valuable and original articles on subjects of general scientific interest. We shall devote a portion of our columns to items of current general scientific news selected and condensed from the best American and European papers and magazines. We have established a corps of correspondents at the various Polytechnic and Scientific Schools, and at the Scientific Departments of the principal Colleges, and from them we shall receive news on all topics of interest connected with their several localities."

We can assure our readers that the Polytechnic answers fully to this specification. And it is perhaps more elegantly "got up" than any other American scientific publication.

A Treatise on Land Surveying, in theory and practice, giving the best methods of surveying and leveling, for statistical, estate and engineering purposes, together with full explanations of the construction, adjustment and use of theodolites, levels and other instruments required in the field and office work of surveying and leveling. By John A. Smith, Civil Engineer, London. Longmans, Green & Co., 1869. For sale by Van Nostrand, New York.

This work is well spoken of by the "Mechanics Magazine," which says:

While on the one hand the author has to travel a good deal in a well-worn path, it is open to him on the other to strike out a few fresh branches, without actually deviating from the main line. He has availed himself of this opening, and also treats the whole subject in that advanced style of mathematical and geometrical investigation which it is now able to bear. In former times, surveyors as a rule, were not educated men in any sense of the term, and a book similar to the one under notice, would not have been appreciated as it deserves to be. At the same time it must not be imagined that the author has plunged into the regions of abstruse mathematics. On the contrary, the formulæ and rules he gives are of a simple and practical nature, and may be easily mastered by any one possessed of that moderate amount of algebraical knowledge which all professional students acquire as a matter of course.

An International Floating Tunnel. By E. W. Young, C. E. London, E. & F. Spon, 1869. For sale by Van Nostrand.

In the plan laid down by the author, it is proposed to construct between Dover and Cape Gris-Nez, a wrought-iron tunnel, in sections of from 200 to 300 ft., to float these into position and lower them into place at a certain depth below the surface of the water, where the joints being made good by divers, they would form one continuous tube across the Channel. Mr. Young thinks that the tube being buoyant it would have to be held down to the proper depth by means of anchor-chains attached to huge blocks of béton. The passage of trains would not materially affect the buoyancy, and the tube being placed below the surface would not be injured by the violence of the waves. Air would be supplied by a number of lighthouses placed along the line of the tube. Numerous sections and illustrations accompany Mr. Young's description, but we fear that his ideas will not receive the support of practical men. We think he underrates the difficulty of submerging and repairing such a tube as that he contemplates, and that he likewise insufficiently considers the terrible influence of the tidal currents on so large a mass.—*Scientific Opinion.*

Society of Engineers' Transactions for 1868.—Spon, 48 Charing-cross. For sale by D. Van Nostrand. 23 Murray street, New York.

In the volume of this Society's Transactions just published, abundant proofs are evident of the increased care bestowed upon it by its editor. The volume contains nine papers, the three first of which by Dr. Edward Cullen, may be classed as one, belonging, as they do, to the same subject—improved communication between the Atlantic and Pacific, *via* the Isthmus of Darien. A paper on Engineering in India, by Mr. C. F. Danvers, and several minor contributions, brought the session nearly to a close, its two final meetings being occupied by Mr. Baldwin Latham's elaborate paper on Steam Cultivation, in which he deals as exhaustively with his subject as he did in his inaugural address, where sewage formed the *pièce de resistance*. To Mr. Latham and to Dr. Cullen, the volume owes the bulk of its handsome collection of finely executed lithographs.—*Engineering.*

A Text Book of Chemistry. A Modern and Systematic Explanation of the Elementary Principles of the Science, adapted to use in High Schools and Academies. By Le Roy C. Cooley, A. M., etc. New York, Charles Scribner & Co., 1869.

THE PRINCIPLES OF PERSPECTIVE ILLUSTRATED IN A SERIES OF EXAMPLES. By HENRY D. HUMPHRIS. Descriptive Treatise and Atlas of Examples. London: Chapman & Hall. 1869.

Mr. Humphris, who is the son of an architect well known in his locality, has issued what is rather a series of examples to illustrate the principles of perspective than an elaborate essay on the science. They are drawn out of good size, and will be found very useful to art-masters, architectural students, and others. Mr. Humphris rightly points out that it would be useless to read the letter-press and look at the plates, and to imagine that a knowledge of perspectives is to be obtained by any such means; while to copy the figures line for line from the examples would be time as badly spent.—*The Builder*.

FIVE HUNDRED AND SEVEN MECHANICAL MOVEMENTS. By HENRY T. BROWN, Editor of the American Artisan. New York, Virtue & Yoston. For sale by Van Nostrand.

The public attention has been largely called to the book, but until every artisan, and especially every mechanician possesses it, we do not think too much can be said of its value. It consists simply of engravings and descriptions of 507 methods of transmitting or changing motion and power, in all the departments of mechanical construction, and running through every variation and combination of the mechanical powers, in gearing, escapements, water wheels, hydraulic machines and miscellaneous machinery. It contains a great many facts and a very little preaching, which is the best thing we can say of any book.

SPECTRUM ANALYSIS.—Six lectures delivered in 1868, before the Society of Apothecaries of London. By HENRY E. ROSCOE, B. A., Ph. D., F. R. S., Professor of Chemistry in Owen's College, Manchester. London, Macmillan & Co., 1869. For sale by Van Nostrand.

It was time that the general public should be made familiar with the grand facts and principles of spectroscopic analysis, and we therefore at the outset publicly thank Professor Roscoe for coming forward as the interpreter between the student of science and the educated members of the community. He has taken upon himself a task whose importance is only equaled by its difficulty, and it is only just to him to express our opinion that he has discharged a complex duty with ability and success. —*Scientific Opinion*.

A MANUAL OF THE HAND LATHE. Comprising concise directions for working metals of all kinds, ivory, bone and precious woods; dyeing, coloring and French polishing; inlaying by veneers, and various methods practiced to produce elaborate work with dispatch and at small expense. By EGBERT P. WATSON, late of the Scientific American, author of "The Modern Practice of American Machinists and Engineers." Illustrated by 78 engravings. Philadelphia, Henry Carey Baird, Industrial Publisher, 406 Walnut street. Price $1.50.

A POPULAR OUTLINE OF PERSPECTIVE OR GRAPHIC PROJECTION; PARALLEL, DIAGONAL, PANANGULAR, GRACEFUL. By THOMAS MORRIS, Architect. London: Simpkin, Marshall & Co. 1869.

THE STEPPING-STONE TO ARCHITECTURE. By T. MITCHELL. London, Longmans, Green & Co.

RAILWAY ECONOMY: USE OF COUNTER-PRESSURE STEAM IN THE LOCOMOTIVE ENGINE AS A BRAKE. By M. L. LE CHATELIER, Ingénieur-en-Chef des Mines. Translated from the author's manuscript by Lewis D. B. Gordon, F. R. S. E., Honorary Member of Institution of Engineers in Scotland. Edinburgh, Edmonston & Douglas.

THE ELEMENTS OF BUILDING, CONSTRUCTION AND ARCHITECTURAL DRAWING. By ELLIS A. DAVIDSON. London and New York, Cassell, Petter & Galpin. For sale by Van Nostrand.

MISCELLANEOUS.

SURFACE CONDENSER TUBES.—Rolled sheet copper is now quoted at about 80*l*. per ton, equal to a little more than 8½d. per pound, although the nominal quotation *by the pound*, is 10d. Solid drawn copper condenser tubes of from ½ in. to 1 in. in diameter, and sold only by the pound, are, on the average 1s. 10d. per pound, showing a charge of at least 1s. per pound, or more than the value of the metal itself, for the mere process of drawing—a process as tedious as it is trying to the metal. The usual thickness of these tubes is No. 18 of the Birmingham wire gauge, or one-twentieth of an inch. By the old process of drawing it would not be safe to make them much thinner on account of the risk of their splitting, the very process of drawing inducing longitudinal weakness, a weakness not found either lengthwise or widthwise of rolled copper sheets. Copper of No. 18 gauge weighs about 2 lbs. 6 ozs. per square foot, and as a foot of ⅞ in. tube would require one-quarter of a square foot of plate, it works out that 2⅜ lbs. of copper would make four lineal feet of such tube, costing from 1s. 9d. to 2s. for metal, and selling for 4s. 4d. equal to a charge of from 7d. to 8d. per foot for drawing alone.

But copper of No. 18 gauge is only employed because of the risk of drawing it thinner. No. 23 gauge, of but half the thickness, and therefore of but half the weight, would be abundantly strong for a small surface condenser tube withstanding but 25 lbs. or, at the most 30 lbs. pressure per square inch, whereas its full strength, if sound, should be equal to an internal pressure of at least a ton per square inch. Yet with No. 18 tubes, which *ought* to withstand two tons per square inch, the highest test pressure adopted by some of our leading marine engineers is but 60 lbs. per square inch. And this is enough, being at least twice what the tube ever has to withstand. If the tubes could be made of half the thickness, that is, No. 23 of the Birmingham wire gauge, they would conduct heat even more rapidly than when of No. 18 gauge, and thus even less condensing surface, and, therefore, even less than half the weight of tubing would be requisite.

But the cost of drawing, viz: 7d. to 8d. per foot, is in itself enormous. The tube machine exhibited at Messrs. Robert Stephenson & Co.'s works during the Newcastle meeting of the Mechanical Engineers, and now again working, we believe, at Messrs. George England & Co.'s works at Hatcham, can convert sheet metal into tubes at a cost, for manufacture, not exceeding half a farthing per foot. The joint made is a mechanical joint only, but it has been tested to more than three times the proof test we have named, and that without the slighest suspicion of a leak. With the success, already reasonably certain, of this mode of making tubes, it will be matter of surprise, if ¾ in. condenser tubes, now costing 13 d. per foot, are not brought down to 5 d. No combination of the simplest mechanical movements has for a long time been announced with any claim to the genuine merits of the American machine.—*Engineering.*

TELEGRAPH ENTERPRISE.—The disposition of the public to pay attention to telegraphic enterprise is attended by the usual result of a multiplicity of projects being hurried out, but the events of 1866 are not yet sufficiently remote to admit of the prospect of danger. The French Atlantic cable being only a few weeks old, a new one from Ireland to Nova Scotia of a light description, to cost £450,000, is now talked of, which is to do the work of the existing cables at half-price. If the capital could be found and the line successfully laid, the shareholders would probably be informed within a month that a fresh one of still lighter construction would be proposed, which, at a further reduction of 50 per cent in the tariff, would still be expected to prove highly remunerative. That the progress of electrical science will ultimately cause the cables of the present day to appear cumbrous can hardly be doubted, but much further experience will be necessary before any very costly experiments in that direction can be ventured upon. It is affirmed on good authority that during the last eighteen years there have been 8,000 miles of light cable laid, some covered with light wire, two consisting of india-rubber core alone, and others protected with hemp and other substances, but that no line of this description has been found to last longer than one year, while in some cases the period has been a few weeks only. All the cables now in working order are of the strong and heavy form, and there seems no example of any kind that can be cited to justify the adoption of the light principle.—*London Times.*

THE OXYHYDROGEN LIGHT scheme has now taken a definite shape in Paris. A company has been formed, the capital necessary has been raised, and application has been made for permission to lay down pipes to carry oxygen and hydrogen over about a fourth of the city. It is not very likely that the permission will be granted, and the promoters will have to confine themselves to supplying individuals with compressed gases, as was originally proposed. We have published the patented processes by which M. Tessié du Motay obtains the oxygen and hydrogen which he proposes to distribute over Parris, at a cost so low that the oxyhydrogen light is promised much cheaper than common gas light; but ingenious and relatively cheap as they undoubtedly are, it is impossible to believe that the service can be made so inexpensive as to supersede coal gas. The prospectus of the company enlarges upon the cheapness and purity of the light, the complete combustion, and the absence of all deleterious matters in the products of the combination; but is quite silent as to the danger of introducing into a house two gases not possessing any smell, and which, consequently, may escape without observation, and the mixture of which forms an explosive compound of far greater power than any mixture of coal gas and air. To any danger of this kind, Continental engineers appear to shut their eyes. We saw, a short time ago, a patent taken out in Belgium for making a mixture of coal gas and air, storing it in gas holders and distributing it over the city of Brussels for heating purposes. The engineering details given, showed a complete knowledge of the subject of the manufacture and distribution of gas, but there seemed to be no recognition of the risk, imminent enough of blowing up the whole concern. A consideration of this kind, some years ago, stood in the way of a scheme of the kind projected for Birmingham, and will, no doubt, prevent the Oxyhydrogen Light Company from getting permissson to lay down their pipes over Paris.—*Jour. Franklin Institute.*

TINTS TO EXPRESS BUILDING MATERIALS.—The following are the conventional tints employed in England, and with little exception, elsewhere among engineers and architects:

Materials.	Color.
Brickwork to be executed (in plans and section..	Crimson lake.
Brickwork in elevations..	Crimson lake mixed with burnt sienna or Venetian red.
The lighter woods, such as fir................	Raw sienna.
Oak or teak............	Vandyke brown.
Granite	Pale Indian ink.
Stone generally.........	Yellow ochre or pale sepia.
Concrete works.........	Sepia with darker markings.
Wrought iron	Indigo.
Cast iron	Payne's grey or neutral tint.
Steel..................	Pale indigo tinged with lake.
Brass	Gamboge or Roman ochre.
Lead	Pale Indian ink tinged with indigo.
Clay or earth..........	Burnt umber,
Slate..................	Indigo and lake.

THOMSON'S ROAD STEAMERS.—The Oriental Coal Company (Limited), into whose hands the extensive coal mines in the island of Labuan have passed, are now working them successfully. In anticipation of a great increase in the demand for coal in the China seas on the opening of the Suez Canal, it has been decided to supply coal at the fine harbor of Victoria, which admits and shelters vessels of the largest size at all times of the tides and at all seasons, instead of at Coal Point, as at present, where steamers can take in coal only in comparatively fine weather. The distance from the mines to Victoria harbor, where the Governor's residence and all the public buildings are situated, is about nine miles, and the coal is to be transported by means of the patent road steamers, with india-rubber tyres, of Mr. R. W. Thomson, C. E., of Edinburgh. Two of these powerful engines and sixteen wagons, to carry six tons each, are already completed, and will be shipped direct to Labuan in the company's new screw collier "the William Miller." These road steamers appear to be exciting great interest all over the world. The Government of India have just ordered to be despatched overland the first engine for a regular service, which they intend establishing on the Grand Trunk Road, for the transport of troops, Government stores, and general merchandise, in lieu of the miserably slow and costly bullock-trains which now creep along that fine road. The road steamers will, it is said, run five or six miles per hour at far less cost than the bullock hackeries, which cannot keep up a third of that speed.

To estimate the force of the tides, all that is necessary is the consideration that the attraction of the sun and moon (principally of the latter), acting in opposition to terrestrial gravitation, elevates the surface of a large portion of the ocean, nearly twice in 24 hours, to the mean height of about two feet. The extent of surface thus raised may be set down at 100,000,000 square miles, or one-half of the surface of the earth, taking this at 200,000,000 of square miles, of which the ocean occupies about three-fourths, or 150,000,000. Every square mile o water two feet thick contains nearly 60,000,000 ubic feet, or 3,840,000,000 pounds of water, an this, multiplied by 100,000, 000, the number of square miles affected by the tide, gives the enormous number of 768,000,000, 000,000,000 foot pounds exerted every twelve and a-half hours, or 7 minutes, which gives, per minute, a power o 100,000,000,000,000,000 foot pounds. Dividing is by 33,000, to reduce it to horse-power, we obain nearly 3,000,000,000,000 horse-power as the total power of the tide-wave over the whole sufa of the earth.—*The Engineer.*

Zinc Sheathin or Ships.—There is nothing novel in the le of preventing the oxidation of iron ships by h use of zinc. Several modes of applying the ac have been suggested by various inventive mls but, for some reason or other, shipowners still y on paint to preserve their ships, and do not se to have faith in the protective power of elecal action. The latest invention for the protec of iron ships by this means is that of MM. Dunce and Bertin, who distribute about the inner e of the shell, tubular reservoirs, made of zinc, ich are riveted to the plates, to place the meta perfect communication with the iron hull. Th reservoirs are charged with sea water, which is nged every day. Bands of zinc carried in all dtions over the inner side of the hull connect thrious reservoirs, and strips are here and there ight to the outer side, and made to communicat th the sea. We need not here explain the actwhich takes place. If the authors can be relioon, the success obtained is perfect. Experimal boats kept in very salt water for a year, they, do not exhibit a trace of oxidation in any —*Mech. Magazine.*

Apprentice em in the shops of the Pennsylvania lway.—Of the 4,087 names on the rolls of thtive Power and Mach. Dept. at the beginninghe year, 114 are designated as "apprentices." to these we were to add such as among the thousand skilled workmen have risen to that chrough apprenticeship, the number would be ised perhaps three-fold or more. Boys are take eventeen years of age,—if possible on their i-day,—and are indentured for four years, recg 75 cents per day for two years, 90 cents the tlear, and $1,00 the fourth. If during this peif apprenticeship their conduct and service leen satisfactory, they receive $124 bonus on the cancellation of the indenture. They afterwards receive, as skilled workmen, from $1,50 to $2,90 per day. Work begins in the locomotive shops with vice-filing, from which the apprentice passes, successively to machine work, running tools, and setting up engines; in carpentry, freight is followed by passenger car work. The result is, in the case of a boy adapted to the work, not only skill in the performance of the different operations involved in car or locomotive building, but a discipline, a system, which admirably fit him to take charge of work; and, accordingly, we find that many of the best foremen, to whose inventiveness and resources the Company owes much every year, are from the class of apprentices who have received technical education in the shops. The system works satisfactorily in every respect. It is sometimes the case that the apprentice, now become an expert, seeks service elsewhere at the end of his term; but with rare exceptions, such return in the course of a year or two.—*Chicago Railway Review.*

The Albany Iron Works' Axles.—The car axles made by Messrs. Erastus Corning & Co., and which have deservedly attained to a great celebrity on the many railways where they are used, are made as follows: Selected scrap or selected puddle-bar made from charcoal (20 per cent) and best anthracite pig, is rolled into 2 by 1 in. bars. These bars are made into a pile 8 in. square with ¾ in. top and bottom made of finished bars. The pile is reheated and rolled to 7 in. round, and this is reheated, forged down and finished under the trip hammer. It is not surprising that these axles never break in service.

Our Index.—Those who have occasion to refer to the back volumes of Engineering periodicals, will admit that, as a rule, the easiest way to find any given article is to begin at page 1 and search for it. Index making has been deemed merely clerical work, as if no professional knowledge were necessary in arranging subjects under the proper headings. We believe the index presented herewith will be found convenient and complete.

The India Rubber Manufacture.—The *North American Review* states that there are now in America and Europe, more than a hundred and fifty manufactories of india-rubber articles, employing from four to five hundred operatives each, and consuming more than ten millions of pounds of gum per annum. The business, too, is considered to be still in its infancy. Certainly it is increasing. Nevertheless there is no possibility of the demand exceeding the supply. The belt of land around the globe, five hundred miles north and five hundred miles south of the equator, abounds in trees producing the gum; and they can be tapped, it is said, for twenty successive seasons. Forty-three thousand of these trees have been counted in a tract of country thirty miles long and eight wide. Each tree yields an average of three tablespoonfuls of sap daily, but the trees are so close together that one man can gather the sap of 80 in a day.

Lighthouses.—According to the *Scientific Review*, a French writer calculated that, at the commencement of 1867, there existed in the world 3814 lighthouses, or phares, of more or less importance, viz: 1785 on the coast of Europe; 674 on those of America; 162 in Asia; 100 in Oceania; and 93 in Africa. As regards Europe, the best lighted coasts are those of Belgium, France following immediately afterwards. Then come, in order in which their names are given, Holland, England, Spain, Prussia, Itlay, Sweden and Norway, Portugal, Denmark, Austria, Turkey, Greece, and finally Russia. Besides Europe, the best lighted coasts are those of the United States, which have one light for every twenty miles, whilst the Brazilian coast has only one for every 87 miles. Of the 2814 in existence at the commencement of 1867, about 2300 had been established since 1830, while the power of the greater part of those existing prior to 1830 has increased.

The Steamship Adriatic.—This fine American built vessel has been purchased by Messrs. Bates & Co., of Liverpool, for the purpose of being converted into a sailing ship. The Adriatic was originally one of the Collins' line of mail steamers, and ran for a time between Liverpool and New York. In 1861 she was purchased by the Atlantic Royal Mail Company, and in the month of April of that year was placed on their line between Galway and New York. Towards the end of 1861 she was chartered by the government to convey troops to Canada, and on her return she was again fitted up as a passenger ship and placed on the Galway line until the whole undertaking collapsed, when she was taken round to Southampton Docks, where she has remained unemployed until the present time. The Adriatic is one of the largest paddle steamers ever built, and her history has been anything but an uneventful one. She was built and fitted up at enormous expense, and now, after lying idle for six years, she has changed hands at very little more than her repairs and fittings have cost. She will make a magnificent sailing vessel, although not adapted for the Atlantic steam trade.

Oroide is the name of a new metallic composition which resembles gold very closely. It was invented in France, and is made by means of 100 parts of copper; 17 parts of tin or zinc; 6 parts of magnesia; 3-6 parts of sal-ammoniac; 1-8 parts of calcined lime and 9 parts of cream of tartar. The copper is at first melted alone; then magnesia; sal-ammoniac; lime and cream tartar are added in small portions under continual stirring. This takes half an hour, then tin or zinc is added, and mixed with the copper by stirring. The crucible in which these operations are prepared, is then covered up and kept in the fire for 35 minutes. The product is cast into bars, which can be rolled, hammered and pressed. It is difficult to distinguish this composition from gold.—*Steirm. Industrie u. Handelsblatt.*

The Vacuum Method of Making Ice.—An ice and cold producing machine has been invented by Herr Franz Windhausen, Brunswick. The action of the machine is based on the principle of producing cold by the expansion of atmospheric air, which is accomplished by means of mechanical power. The machines require no chemicals, nothing being used in them but water and atmospheric air. They may be wrought by steam, water, or wind, and they produce from 100 to 1,000 lbs. of ice per hour, according to size, at a cost of from 2d. to 5d. per 100 lbs.; this difference resulting from the varying prices of fuel and the mode of working chosen. One of their uses is to cool rooms, cellars, theaters, hospitals, compartments of ships, etc.—*Builder.*

The Smoke Nuisance.—Dr. Angus Smith has experimented on smoke of various degrees of blackness and brownness, and he shows that the difficulty of consuming smoke does not commonly arise from a deficiency of air in the furnace, but from the fact that a rapid draught often fails to allow time for proper combustion. It is now certain that the black smoke prohibited by Act of Parliament contains carbonic oxide, one of the most poisonous of gases. Carbonic oxide is only detected in smoke of the illegal density, and when we find that this black smoke is really an expensive article to produce we seem to be furnished with every reason why such a nuisance should be prohibited.

The Bermuda Floating Dock.—Although predictions of disaster as to her voyage out were plentiful, the great Bermuda dock has arrived safely at the island. The passage was made, it would appear, under favorable circumstances. The absence of suitable dock accommodation at Bermuda has long been felt, and now that this want has been so well supplied, war ships on the North American and West India stations can be overhauled and repaired, instead of being sent home for those purposes.

The Wire Tramway Com.ny have contracts at present in execution in France for about 25 miles of wire tramway, all f beet sugar makers. Mr. Hodgson, the inventor, is at present engaged constructing the line for the estaena Company in the Alps; besides this, the compy have contracts in Spain, Sweden and Austria, and are shipping lines to New Zealand and Peru. Several short lines are in course of construction England, and the difficulty of obtaining right way is alone preventing them doing a large siness in this country.

Shape of Screw Taps.—Mr. W. A. Sweet of Syracuse, informs us, referring an article we translated on page 976, from a German Magazine, that he commenced a lathe for the e purpose in 1864, that he then learned that Mes Wm. Sellers & Co. had the same idea, and the e has quite recently seen at the works of Messrs enyon & Co., Steubenville, O., a lathe for cutti taps on this principle, made thirty years ago, in use ever since. In this lathe, however, groove has a curved bottom which will not c-a great improvement on the German idea.

The Largest Span of any truridge in the United States is that of the gridge across the Ohio river at Louisville, whic destined to connect the Kentucky and India hores. The bridge itself will be, when finished the engineer in charge expects to turn over contract for the building some time in Novem, one of the most splendid structures of the k this or any other country. This last span c three hundred and seventy feet, and is a ma f engineering skill.—*Engineer.*

British Steam Vessels.—An cial return shows that down to the 1st uary, 1869, there had been registered at the p the United Kingdom 2,916 steam vessels, the egate registered tonnage being 904,191 tons their gross tonnage 1,341,106 tons. The dat uild ranges from 1823 to 1868; the oldest is And Jane, of Newcastle, of 27 tons.

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